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THE IMPERIAL COLLEGE OF TROPICAL AGRICULTURE, TRINIDAD, B.W.I.

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LOW TEMPERATURE RESEARCH.

THE future of the College Low Temperature Research Station is uncertain. It would indeed be unfortunate if its work were to cease for lack of the necessary support as the problems it has still to tackle are many and important. From its inception it has supplied information not only of practical use to various trade interests but also of great scientific value. Its work, at first confined to studies of the behaviour during storage of banana varieties immune to Panama disease, was subsequently extended to include problems covering a wider range of tropical products. At the present juncture a review of the Station's activities may not be out of place.

When the Banana Research Scheme was launched, three main lines of attack on Panama disease, the major problem at issue, were envisaged. In the first place experiments were begun on the breeding of a new variety resistant to the disease. This work, at present under the direction of Professor Cheesman, is still in progress, and so far two new immune varieties have been produced of which one shows particular promise. In 1928, Dr. Wardlaw was appointed as plant pathologist to make a special study of the second phase of the problem—the fungus itself. A very exhaustive account of this work will be found in his book on "Diseases of the Banana"*. As a result of his researches, Dr. Wardlaw established that the organism responsible for Panama disease was closely connected with lack of fertility and with adverse soil conditions. While it is possible that by suitable soil treatment the disease might be held in check, the general conclusion arrived at was that a complete solution of the problem would eventually lie in the breeding or discovery of a resistant type of banana.

When the late Dr. McGuire was appointed plant physiologist, work was begun on the third aspect of the problem which was to include the study of the behaviour in storage and transport of the banana. Most of this work was carried out in the Low Temperature Research Station. From extensive storage and ripening trials it was found that the Lacatan and Cavendish bananas varieties appeared suitable substitutes for the Gros Michel, which is the chief commercial variety grown. In addition, definite measures for the prevention of various banana rots were put forward, while measures for the reduction of

* See also *E.M.B.* 20.

wastage in, and the improvement of, crated cargoes of bananas were submitted. Attention was next directed to the question of rapid cooling which was believed to be an important preventive measure in the control of banana diseases. As a result, the nature and limits of chilling effects were more accurately defined. It was moreover established, contrary to previous experience, that rapid cooling could be practised without danger of chilling. Precise information was subsequently obtained regarding actual hold conditions during the transport period from the Caribbean area to English ports. From detailed observations on hold conditions throughout this period much information regarding temperature and humidity factors and the effects of stowage on production of mechanical damage, and subsequent wastage, was obtained. Concurrently, at the Low Temperature Research Station, the activity of the more important banana pathogens, under conditions approximating to those actually recorded on ship board was investigated in greater detail. From these investigations it was clearly demonstrated that the worst aspects of wastage were the result of injury and infection at tropical temperatures. Attention was called to the importance of careful handling, of curtailing to the minimum the time between the reaping of fruit and cooling in the holds, of careful selection of the fruit and of tight stowage. Finally, the storage and behaviour of the Giant Governor were examined in some detail and comparative observations made with the new College hybrid I.C.2. The Cavendish was found to display many of the qualities which fit the Gros Michel for trans-oceanic shipment while promising results were also obtained with the College hybrid which possesses the more attractive qualities of the Gros Michel. These are, in brief, the results of the physiological researches* on the banana.

From 1930 onwards, the need for inaugurating and expanding exports of West Indian and tropical fruits generally has been continuously before the planting community and administrative officials concerned. The realisation that lasting success could only be assured if the way was prepared by thorough scientific investigation of relevant biological aspects, resulted in a modification of the function of the Station, namely that research should not only be confined to banana problems, but should also be extended to include tropical vegetable produce generally. Implicit in this enlarged research programme was the understanding that the many and varied aspects of fruit and vegetable storage to be examined would call, not only for direct investigations on immediately practical issues, but also for more fundamental research on those problems which cannot be solved by empirical experimentation. Accordingly, while attention has and is still being paid to the banana and particularly to the Cavendish and its various mutants, various investigations on storage temperatures, humidity relationships, methods of packing, handling, shipment and ripening have been carried out for tomatoes, West Indian and hybrid limes, oranges, grapefruit, avocado pears, mangoes, papaws and a collection of miscellaneous fruits and vegetables. The results of the experiments on the storage of tomatoes* have been published by the Empire Marketing Board and of the other investigations as memoirs of the Station, reports, and articles in this Journal. Judging from the demand for these publications from various parts of the world the work of the Station would appear to have created a good deal of interest.

The Station has acted in an advisory capacity on a number of occasions. In 1933, at the specific request of the New Zealand Government an investigation was undertaken covering the export of bananas from Samoa and Niui Island to New Zealand. Another special request took the officers of the Station to Santos, Brazil, in 1932, to investigate problems of banana disease and transport for a British Company. During recent years officials of various steamship companies have kept in close touch with the officers of the Station on matters of fruit storage, ventilation, the refrigeration of holds, &c. During the past year the Trinidad Cooperative Citrus Growers' Association has been constantly supplied with advice on practical matters and recently the local pre-cooling of a shipment of 3,000 crates of grapefruit—the first trial of its kind—was conducted entirely under the supervision of the Station. As pathologist and officer in charge of the Station, Dr. Wardlaw has also been responsible during the last two years for making diagnoses of new and important banana diseases in the West Indies, notably Moko disease (*B. solanacearum*) on the Gros Michel and Sigatoka disease (*Cercospora musae*).

For the first five years of its existence the Station has been supported by a grant from the Empire Marketing Board, but when that Body ceased to function funds were only provided on a year to year basis and on a reduced scale. As matters stand at present, the research scheme is due to terminate in September unless further funds are forthcoming. Enough has already been said on the extensive scope of the Station's activities. It will be obvious to all those vitally interested in the development of the fruit and vegetable trade in the West Indies and in other parts of the Empire that the advice of the Station will be greatly missed in the event of its work being discontinued, but there are hopes that even at this late stage funds will now be forthcoming on a scale sufficiently generous to enable the work of the Station to go on for a further period of years.

* *E.M.B.* 36, 45, 60 and 72.

* *E.M.B.* 59.

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THE STORAGE OF TRINIDAD CITRUS FRUITS.*

In this Memoir a preliminary account is given of investigations carried out at the Low Temperature Research Station, Imperial College of Tropical Agriculture, on the storage of grapefruit and oranges in Trinidad with particular reference to wastage. Three major sources of deterioration are discussed: (i) blemishing and slackness due to loss of moisture, (ii) chilling or low temperature injury, and (iii) fungal wastage. An attempt has been made to study the behaviour of citrus fruit between picking—through quailing, packing-shed treatment, preshipment storage with or without refrigeration, storage during transport—and subsequent distribution. The author's conclusions and recommendations are as follows:—

"(i) In general, Trinidad Marsh grapefruit compares favourably as regards storage behaviour with that grown elsewhere, during the first five weeks from picking and under the storage conditions used during 1934-35 at the Low Temperature Research Station. Where more prolonged storage is required, the possibility of considerably increased fungal wastage and blemishing due to chilling or desiccation have to be envisaged, but given optimal storage conditions, as yet unascertained, there is no good reason to suppose that Trinidad fruit should not fulfil expectations. Some modification of the existing practice at the Low Temperature Research Station is evidently necessary, chiefly to reduce loss of moisture.

(ii) Reduction of the period between picking and cold storage is essential to minimise loss of moisture and the onset of fungal wastage; further experiments are necessary to determine the minimum quailing period required.

(iii) It has definitely been established that 40°F. is too low a temperature for storage, chill blemishes being produced after about 10 days with subsequent enhanced fungal wastage. In the absence of more precise knowledge, 45°F. is recommended as a storage temperature, delivery air, where the battery system is employed, to be at this temperature. Where only grid cooling is available the minimum air temperature should likewise not fall below 45°F. and some form of air circulation or distribution should be attempted wherever possible to obtain uniformity at approximately the temperature recommended: unless this is available, losses due to chilling are inevitable and non-refrigerated transport preferable.

Where circumstances necessitate local pre-cooling, this should be as rapid as possible, subject to the temperature limit stated above. It is further recommended that pre-cooled fruit should not be retained in local stores for long periods but should be shipped with the utmost despatch; this is in relation to paragraph (i) above.

(iv) A detailed survey of the condition of fruit subject to temperatures simulating non-refrigerated transport has confirmed a view expressed earlier that this method, whilst involving increased fungal wastage and desiccational blemishing, is nevertheless practicable and may be resorted to in the absence of suitable refrigerated transport.

(v) The tolerance of Trinidad grapefruit to concentrations of carbon dioxide and oxygen has not been studied. This is chiefly of importance where no air circulation is provided in storage. High concentrations of carbon dioxide up to 25 per cent. have been found by other workers to be non-injurious to citrus fruits. On arrival at Southampton maximum concentration of 11.5 per cent. Co_2 have been recorded in ships from South Africa.

(vi) The fungi appearing as pathogens have been studied. Three organisms, principally, are involved in wastage. It is to be noted that the incidence of each is quite distinct and accordingly will call for remedial measures differing in application and kind. So far it has not been possible to determine that geographical locality exercises any clearly marked effect on wastage. Plantation sanitation, on the contrary, was obviously of profound importance. Fungal wastage decreased during the course of the season.

(vii) The Foster variety shows storage behaviour similar to that of the Marsh.

(viii) Fruit from trees affected by gummosis has been apparently normal in its storage behaviour but that from root-rotted trees is definitely abnormal and should not be exported."

In regard to storage trials carried out with four different varieties of oranges the author states:—

"(i) *Cocoa Oranges.*—This variety requires careful handling, a minimum quailing period and storage at 45°F. In spite of its somewhat unattractive appearance when untreated, ethylene colouring is inadvisable owing to the increased loss of moisture and fungal wastage consequent on prolongation of the exposure at high temperatures.

(ii) *Valencia.*—Given early cold storage after picking, and carriage at 45°F. this variety as grown under Trinidad conditions appears suitable for export.

(iii) *King Oranges.*—Green or turning fruit stored at 40°F. showed slight wastage and no increase in maturity after 27 days when previously quailed, or 32 days when stored directly. Since no chill effects were observed this temperature can be recommended for export of this variety.

(iv) *Satsuma Oranges.*—It is evident that if Satsuma oranges in Trinidad are to be exported without serious wastage being incurred (*a*) great

* E. R. Leonard.—The Storage of Trinidad Citrus Fruits, Memoir No. 2 of the Low Temperature Research Station, Trinidad, pp. 47 and 12 figs. Copies, price 2*s.*, may be obtained on application to the Editor, *Tropical Agriculture*, Imperial College of Tropical Agriculture, Trinidad, B.W.I.

care must be taken in handling, (*b*) the fruit must be picked at an early stage in ripening, (*c*) it must be protected from desiccation, *e.g.*, by the use of tinfoil or other moisture-retaining wrapper, (*d*) the delay between picking and cold storage must be minimised, (*e*) storage should be at 40°F., distribution after cold storage must be rapid."

A comprehensive report on the storage of a consignment of grapefruit in a local cold store is appended. This is a record of observations made during the pre-shipment storage of a consignment of crated grapefruit, the first of its kind in Trinidad in a commercial cold store. The findings are summarised as follows :—

"1. Observations were made on air temperature, humidity, vitiation and flow, flesh temperature, and fruit condition in a consignment of grapefruit in a commercial store refrigerated by means of the cold blast system.

2. Loading—The stowage plan adopted appeared to be quite satisfactory and provided a vertical space is left under the delivery trunk no damage should occur due to condensation drip. Such a vertical 'break' would have the further advantage of allowing the vertical delivery of cold air to descend to the floor and ensure more uniform distribution.

3. Temperature records indicate that the rate of cooling was slow, a mean air temperature of 60°F. being reached after 3 days, 50°F. after 5 days and 45°F. only after 12 days, the flesh being reduced to these values after 3 and 6 days, 45°F. not being reached by any crate of fruit.

4. Where the pre-shipment period is of relatively brief duration, and in order that optimal use may be made of the refrigeration available, it is desirable that the storage temperature of the fruit should be reduced as quickly as possible to 45°F. by delivery air at that temperature.

5. Relative humidity remained at about 85 per cent.

6. Air vitiation was negligible.

7. An air delivery of about 300 cubic feet per minute was supplied giving a change of air about once every 18 minutes ; this was later reduced to 136 cubic feet per minute, changing the air once every 40 minutes and involving a slightly increased gradient of temperature across the room.

8. Over a total of 14 crates examined (1,100 fruit) the loss in weight was negligible, blemishing slight and wastage due to fungal rots 1 per cent. this last showing considerable variation from crate to crate."

Detailed descriptions are included of the Low Temperature Research Station storage equipment and of the refrigeration system of a local cold store.

The Memoir should be particularly useful not only to those engaged in storage researches elsewhere but also to those concerned with the actual production of fruit and with all operations germane to packing for export, shipment and distribution in centres of consumption. In addition to purely practical aspects, the fundamental biology involved in handling this produce has been kept in mind throughout.

OBSERVATIONS ON COFFEE IN KENYA*.

Part I—Chlorosis and Dieback in Coffee.—*V. A. Beckley.*

The author maintains that chlorosis followed by dieback in coffee may be attributed to two principal causes. In the one case nitrogen deficiency is held mainly responsible, and in the other carbohydrate deficiency. The early symptoms of both are similar, foliage first paling and the main veins then turning yellow. Subsequent changes are, however, distinguishable. Where nitrogen deficiency is responsible nearly mature leaves are shed and the yellow terminal leaves and growing points die, the leaves usually dropping as death occurs. Progressive dying-back of branches may follow. This frequently occurs among the middle primaries. The crop suffers severely, for although outwardly the cherries (fruits) may appear normal, inside breakdown or shrivelling starts at one end of the endosperm, and most of the beans may be lost in this way. The roots do not appear to be appreciably affected and have always been found to contain large quantities of starch as may be simply demonstrated by putting iodine on a cut. Where chlorosis is due to inadequate carbohydrate supply, dieback does not begin terminally, but usually where the green immature wood starts. The death of the apical leaves follows, but they are frequently retained for some weeks before dropping. Subsequent death of the branches is as before. The crop in this case does not suffer appreciably and even cherries on dead apical shoots will contain some residue of a bean. Lateral roots show severe dieback leaving scars on the main stock root. Tests for starch are negative. The ultimate effect of this chlorotic condition is much more severe than is that caused by nitrogen deficiency, the trees taking at least two years instead of one to recover. Moreover, when nitrogen is deficient the application of a readily available nitrogenous manure will arrest breakdown of the crop and produce conditions of normality the following year. This does not apply in the case of carbohydrate deficiency, but nitrogen, if applied at setting of the fruit or when the first sign of chlorosis is evident, will encourage the formation of a larger leaf area and thereby stimulate photosynthesis and carbohydrate formation indirectly. Two other forms of chlorotic condition have been recognized, but no definite cause has yet been determined.—(*Imp. Bur. of Fruit Prod.* Hort. Abs. Vol. V, No. 3. Abs. 467, pp. 175-6, 1935.)

* *Emp. J. Exp. Agric.* 1935, 3 : 203-9.

SOME ECONOMIC ASPECTS OF CACAO PRODUCTION IN TRINIDAD WITH SPECIAL REFERENCE TO THE MONTSERRAT DISTRICT.*

By C. Y. Shephard.

Introduction.

I shall attempt, this afternoon, to give you a brief summary of certain work on cacao carried out by my Department. Let me make it perfectly clear at the outset that we claim no important or original discovery. Whatever merit our work may possess is due to the generous co-operation of the scientists of the College and the Department of Agriculture, and of the cacao planters throughout the Island. The economist is concerned with both the craft and science of agriculture, but only in so far as they affect the profit of the agriculturist. The Department of Economics is merely a clearing house, which collects the varied experiences and ideas of planters and scientists, conducts them through mysterious rites and ceremonies, and re-issues them in a completely unrecognisable, unintelligible and indigestible form for public consumption.

The objects of our investigation have been :—

(i) to discover *which* estates are profitable and which unprofitable ;

(ii) to find out *why* certain estates are profitable and others unprofitable ; and

(iii) to ascertain *whether* the unprofitable estates can be made profitable and the profitable ones more profitable.

The survey which we conducted throughout the length and breadth of the Island during 1929-30 and 1930-31 showed that high yields per 1,000 pickets, or per acre, were accompanied by low costs of production and large profits. Conversely, low yields are accompanied by high costs of production and low profits. High yields per acre must be our aim.

What factors are responsible for high yields ? Are they due to efficient management ? If you happen to be the manager of a high yielding profitable estate, I must run the risk of incurring your displeasure by stating that those happy results are not primarily, nor even largely, due to the efficiency of your management. On the other hand I can console the managers of low-yielding unprofitable estates by asserting that those distressing results are not primarily, nor even largely, due to your inefficiency. To prove my point I need do no more than point to the fact that some managers of outstanding ability have, under their control, both high and low yielding estates. Efficient management certainly plays its part in determining the profitableness of an estate, but the rôle is, at present, a subordinate one.

Are high yields due to intensive cultivation ? The answer is, "no" ! In fact, the highest yielding estates spent considerably *less* per acre on every item of cultivation than the average, while the lowest yielding estates spent considerably *more* than the average. I trust that owners will not draw the deduction that a decrease in expenditure on their cultivation will result in increased yields ! On the contrary, the enforced neglect of cultivation during the present depression has resulted in diminished yields.

Influence of Soil-types on Yield.

The fact is that yields in the cacao districts of Trinidad are determined primarily by two factors which are only partially within the control of the manager. They are (i) soil, and (ii) the age of the cultivation, and of these soil is by far the more important. I should like, at this stage, to state that our work on various soil types has been made possible only by the generous co-operation of Professor Hardy and Mr. McDonald. With their assistance we have collected comprehensive data concerning the four principal soil types in the Montserrat District, and are now engaged in a similar investigation in the Rio Claro District. To-day I shall be concerned solely with the Montserrat District. There is no time to examine the whole of our results, but I think that my contentions regarding the paramount importance of soil type can be illustrated by reference to three fields of approximately the same age, 45 to 50 years, situated on Chocolate, Alluvial and Brasso Clay soils. These soils are fully dealt with in the "First Annual Report on Cacao Research 1931", and in "The Cacao Soils of Trinidad ; the Montserrat District". We are concerned only with their relative productivity which is clearly illustrated in the diagrams now before you.

Each small square represents a picket, and the yield is indicated by the density of the hatching or shading. Thus, a black square represents a tree yielding more than 6 lb. of cacao. A white square represents a 'blank', or a tree giving no yield, or next to no yield. Between these two extremes are shades representing different yields. Hence, the darker the general impression of the picture, the higher the yield ; and the lighter the picture, the lower the yield.

It will be observed at once that there is a marked contrast between the fields on Chocolate and Alluvial soils, and that on Brasso Clay soil. The Chocolate and Alluvial fields are very dark, indicating exceptionally high yields. The Brasso Clay field is almost white, showing a desperately low yield. The actual yields in this year, which was a good one, were 14½ bags * per 1,000 pickets † on the Chocolate, 13½ bags on the Alluvium, and 1½ bags on the Brasso Clay. Unfortunately there exist no field records of expenditure but an analysis of the average annual expenditure on the

* 1 bag=165 lb.

† 1,000 pickets=1 carré=3⅛ acres (when trees are planted 12 ft. × 12 ft.).

* Being the substance of an address delivered to Trinidad planters at the Imperial College of Tropical Agriculture on 20th February, 1936. None of the diagrams referred to has been reproduced.

three estates over a seven-year period shows that the cost of labour for cultivation alone amounted to $6.05* per acre on the Chocolate estate, $7.58 on the Alluvial, and $6.60 on the Brasso Clay. Thus, for approximately the same expenditure, the Chocolate soil yielded ten times, and the Alluvial soil nine times, that of the Brasso Clay. There, briefly, you have the relative worth of middle aged cultivation on two good soils and one bad one.

These fields merit rather more detailed examination. Let us first take the Brasso Clay field. We will put into one group all the pickets giving no yield at all; then we will put into another group all those producing from 1/10 lb. to 1 lb. of cacao; then, those producing more than 1 lb. but not more than 2 lb.; and so on. When we examine our results we find that no less than 62 per cent. of the pickets produce not a single bean! Just pause for one moment to consider the significance of these figures. If we imagine all these pickets collected together into one patch, instead of being distributed over the whole field, it would be possible to walk through an area representing more than 3/5ths of the field without finding a single cacao pod! Yet these ungrateful pickets demand more or less the same expenditure on cutlassing, draining, pruning, &c., as their more generous neighbours. It is true that of this 62 per cent., some 15 per cent. are blanks, and 6 per cent. young supplies, but there still remains 41 per cent. consisting of more or less mature trees giving no yield.

Our next group, representing trees giving between 1/10 lb. and 1 lb. of cacao, accounts for another 31 per cent. of the pickets. Consequently we are left with only 7 per cent. of the pickets yielding more than 1 lb. of cacao apiece. This small band of heroes is responsible for 51 per cent., or more than half of the total production of the field.

There is another aspect of this field which is of equal interest. Of the plants used to establish it 45 years ago, only 27 per cent. have emerged unscathed. In other words, some 73 per cent. of the original plants have become partial or complete casualties, and have had to be replaced, at least once, by suckers or supplies. These figures suggest an excessive rate of mortality on Brasso Clay soils.

Let us now compare the results of this Brasso Clay soil with those obtained on the Chocolate and Alluvial fields of similar age. The pickets giving no yield amount to 16 per cent. on the Chocolate, and 18 per cent. on the Alluvial soil, compared with 62 per cent. on the Brasso Clay field. The good soils therefore harbour less than 1/3 of the number of entirely non-productive pickets found on the poor soil. Blanks account for only 2 per cent. on the Chocolate, and 1 per cent. on the Alluvial, soil. These percentages are exceedingly low and signify that every reasonable site is occupied. Young supplies represent another 10 per cent. on the Chocolate, and 7 per cent. on the Alluvial, field. We are therefore left with only 4 per cent. of the pickets, consisting of more or less mature trees producing no cacao on Chocolate soil, and 10 per cent. on Alluvial soil. Contrast these figures with 41 per cent. on Brasso Clay! When we turn to the trees yielding more than 1 lb. of cacao we find 63 per cent. on the Chocolate, and 47 per cent. on the Alluvium, contrasted with only 7 per cent. on the Brasso Clay! The good soils are therefore vastly superior to the poor soils in the percentage of profitable pickets.

Nature of Damage.

When we examine the number of casualties we find far less contrast between the good and bad soils. No less than 65 per cent. of the trees planted 48 years ago on Chocolate soil have been replaced, and 46 per cent. of those planted 49 years ago on Alluvium. The Alluvium is notably superior to the Chocolate and Brasso Clay soils in this respect, and it is surprising to find that the Chocolate soil, despite its outstanding fertility, has only 8 per cent. fewer casualties than Brasso Clay.

Having assimilated these figures you will be impatient to learn the cause of these casualties. Let us first turn to a Brasso Clay field. On the large diagram now before you we have endeavoured to superimpose in colour the nature of the factors responsible for poor yield. You cannot fail to be struck by the large stretches coloured green. These represent landslips. The production on these areas has been reduced almost to zero, and, as you see, they comprise a very large portion of the field. Unfortunately, cacao cannot be re-established on these landslips until the newly exposed surface has undergone weathering for a number of years. Young supplies make no growth and usually die, presumably owing to the presence of calcium sulphate, or gypsum, in excessive quantities. Landslips therefore occasion almost complete lack of fertility, and on some old fields it is almost impossible to ascertain where one landslip ends and the next begins. Fortunately these areas neither merit nor receive much cultural attention.

Turning to other portions of the field you will notice a large number of squares coloured light blue. This colour represents a spindly, unhappy, thriftless tree with a poor canopy. Purple squares, too, are very prevalent. They indicate dead trees. Many pickets are painted yellow to show that at least 50 per cent. of the mature pods were black at the time of counting. In the diagram above, which shows the same field in 1932-33, numerous trees were defoliated by thrips. These are picked out in orange. Beetle damage was also marked. By this time we had exhausted our range of colours. All the Brasso Clay fields suffer severely during drought, and become waterlogged after heavy rains. In brief, this Brasso Clay field appears to suffer from almost every imaginable thing. You will observe that nearly every picket carries one or more tint, the principal exceptions being the small percentage of comparatively good bearers.

* $1 = 4*s.* 2*d.*

We now turn to our Chocolate field. You will be struck by the marked contrast in colour. No square is coloured green or purple because this soil does not suffer from landslips, nor do the trees simply fade away. Thrips and beetles cause very little damage. Yellow, however, is even more prevalent than on Brasso Clay, and marks heavy losses from black pod. The most widespread colour is red, representing trees damaged by falling immortelles. There is hardly a patch of low yield which is not associated with a fallen immortelle. Canker, overshading by neighbouring trees, and injuries from a variety of causes, are responsible for a number of poor bearers, but the most important factor is undoubtedly the damage caused by immortelles. No picket has been recorded as damaged by an immortelle unless there remains strong circumstantial evidence in the shape of the fallen immortelle. On this diagram we have sketched in the fallen immortelles. You may be under the impression that this diagram is too good to be true, but let me assure you that it is too true to be good.

The nature of the damage inflicted by falling immortelles is worthy of closer examination. Some trees are smashed, smothered and obliterated. Some are split through the trunk. Others have one or more main branches torn off, and still others lose only a few small branches. In some instances the injury has taken the form of a crude and severe pruning, which resulted in increased yields, and induced Mr. Robert de Verteuil to experiment with the topping of excessively high cacao trees.

Those trees which are severely injured, but not killed, present the most important and difficult problem. Had they been killed they would have been replaced by a supply, but too few are killed, and too many are mauled by the immortelle. Our records suggest that badly damaged trees will never yield as much as uninjured trees of the same age, and it is the presence of these trees, occupying their fair share of the land, but giving year by year a poor yield, which constitutes the main problem to be tackled on Chocolate soil.

Falling immortelles are also the largest single cause of low yield on Alluvial and Brasso Sand soils, but the damage is not so extensive for the following reasons :—

(*a*) the immortelles do not grow to such an enormous size, and

(*b*) these soils occupy more sheltered sites, and fewer immortelles are blown down. The damage caused by the immortelle is least on the Brasso Clay, despite the exposed sites, because a different variety of immortelle (the Bocaré) is used, and it attains a much smaller height and girth than the Anauca does on the good soils, and therefore offers less resistance to wind, and causes less damage when it falls.

Influence of Age of Cultivation on Yields.

I stated that the second most important factor determining the profitableness of cacao estates is the age of the cultivation. Our survey of the three years 1926-7 to 1928-9 showed that estates less than 25 years old gave yields 2.37 bags per 1,000 pickets in excess of any older age class, and produced at a cost of $2.91 per bag less than the next oldest class. These groups of estates, however, contained many different soil types, and it is preferable that we should consider the effect of age in relation to individual soil types.

With this object in view we endeavoured to find in the Montserrat District fields ranging from, say, 15 to 80 years old on each of the four principal soil types. Our search was unsuccessful for a most interesting and instructive reason. The Spanish squatters, who penetrated into the forests of the Montserrat District about the middle of the 19th century, confined their attentions to the good Chocolate, Brasso Sand and Alluvial soils, and completely ignored the poor Brasso Clay soil. In so doing they exhibited a keen appreciation of soil values. The French planters who consolidated the small Spanish holdings into large estates from the 70's onwards utilised large areas of Brasso Clay for cacao planting. Let me divert for one moment to say that the French planters were thoroughly justified at the time in planting cacao on Brasso Clay soil. High prices, cheap labour, and the fairly good yields obtained from young cultivation rendered these estates highly profitable to their owners. The point which concerns our immediate discussion is that we were unable to find any cultivation on Chocolate soil *less* than 50 years old, and none on Brasso Clay *more* than 50 years old. I have already described fields of the same age on different soils to illustrate the fundamental importance of soil type. In the case of Brasso Clay soil I can carry the story further to show the influence of age.

On the diagrams before you are represented the yields of fields on Brasso Clay soil ranging from 20 to 45 years of age. You will note that the cultivation 20 years old gives reasonably good and profitable yields. Even here, however, there is unmistakable evidence of landslips. The fields 25 years old exhibit rather more general signs of deterioration. On the 30 year old fields large areas are quite unproductive. At 40 years old a few patches of fair yield stand out vividly against wide barren areas. By 45 years we are reduced to a few individual high bearing trees thrown into high relief by wide expanses of white. Yields have fallen to about ¼ lb. per picket, now hardly worth the cost of picking and preparation.

Surely these diagrams prove conclusively the need for field records ! It is obvious that if the yield throughout the estate had fallen to the low level of the 45 year old cultivation the annual expenditure would vastly exceed the income. The fact is that the young fields more than pay for their keep, and are drained of their profits to support the infirm old fields. Field records would reveal those areas which no longer offer the possibility of profit, but I despair of introducing so revolutionary and so business-like a change into the time-honoured methods of managing cacao estates in Trinidad.

The pickets on every one of the fields before you have been analysed in the same manner as the three fields I described in detail, but the diagrams tell their story so clearly that I need not detain you with further diagrams and statistics concerning them. I have already explained the factors associated with age which are responsible for declining yields on Brasso Clay soils. Landslips destroy trees; waterlogging, drought, thrips, beetles, falling immortelles, &c., reduce their vitality, and depress their yields, faster than young supplies can be brought into bearing. In case you may be under the impression that the neglect of cultivation during recent years has been entirely responsible for the decline in yields, let me state that every field under 20 years of age has shown an upward trend of yield, while fields over 25 years of age, with a few exceptions, have shown a downward trend of yields. The exceptions are those fields which have been rehabilitated in a manner I shall shortly describe to you.

Our work has not been carried on long enough for me to show you the effect of time on individual pickets. I should, however, like to draw your attention to two coloured diagrams of the same Brasso Clay field, one representing the yield given in 1932-33, and the other the yield given in 1934-35. In the latter year the green colouring is much more extensive, indicating new landslips. The number of pickets carried away by landslips during the two years between our examinations represented 6.1 per cent. of the total. My reason for detaining you with these diagrams is to point out that in 1932-33, these pickets contributed only 1.6 per cent. of the total yield. In other words they gave little more than one quarter of the average yield of all the pickets. An inspection of the coloured diagram for 1932-33 shows that the pickets subsequently affected by landslips were nearly all dead, dying, damaged, poor, miserable, spindly trees, or young supplies used to replace dead trees. Not a single tree could be classified as a good bearer. An area of poor yield on Brasso Clay soil usually indicates an old, or an incipient landslip.

I have already stated that we have no young field on Chocolate soil, but fortunately we have records of field yields going back for many years. Only two, however, go back to what may be termed the critical years and these show that the highest yield was obtained when the cultivation was about 30 years old. We have, however, older fields on Chocolate, Brasso Sand and Alluvial soils ranging up to 80 years. The striking feature of these fields is that there is no continuous decline in yield with age. In fact, some of the oldest fields give the highest yields, although we are told that they gave very much greater yields when they were 20 to 30 years old. The yield of the older fields appears to be determined largely by the number of trees which have escaped severe injury. If we compare the yield of each individual picket on our Chocolate field in 1931-32 with the yield in 1934-35, we find that extensive damage may occur within a very short time. This group of pickets, for example, gave a very high yield in 1931-32 and nothing in 1934-35. Here is a similar patch, and here another. The reduction in yield has been due, in each instance, to falling immortelles. On the other hand a few trees have shown some recovery. The net result is a substantial reduction in the number of good bearing trees which may or may not be remedied in the future.

It will now be quite evident to you that the problem which confronts us on Brasso Clay soil is quite different from that on Chocolate soil. On the Brasso Clay soil, trees are carried away by landslips, and the reduction in the number of pickets cannot be made good for many years owing to the presence of gypsum in the newly exposed surfaces. We are therefore faced with a rapidly diminishing number of bearing trees. Careful drainage and heavy pruning will provoke a moderate response, but the planter is fighting a losing battle, and such efforts can be regarded only as a costly rearguard action.

The prospect on the Chocolate, Brasso Sand and Alluvial soils is infinitely more encouraging. There is nothing wrong with the soil; at least nothing which cannot be remedied by judicious manuring. The oldest trees give the highest average yield. There is no evidence of senility in the trees on these soils as there is on Brasso Clay. Like good wine they improve with age. Look, for example, at this diagram. Here we have more than 50,000 trees, grouped according to age, on each of the four soil types. The average yield is greater with each successive age class on the Chocolate, Brasso Sand and Alluvial soils. Chocolate is outstandingly good. Trees 70 years old, the oldest we have, give an average yield of $5\frac{1}{4}$ lb. Brasso Sand is slightly superior in the younger age classes but does not show the same increment of yield after 50 years, so that those 70 years old give an average yield of $3\frac{3}{4}$ lb. Alluvium is not quite so good as either Chocolate or Brasso Sand in any age class, and at 70 the average yield is slightly over 3 lb. I should explain that the high yield of the old trees is probably due, in large measure, to the space which they occupy. Neighbouring trees have become casualties and afforded the uninjured trees an opportunity of expanding. If confined to a space of 12 feet by 12 feet, their yields would not be so impressive.

Contrast these results with Brasso Clay! In every age class the average yields are markedly inferior to the good soils. They never exceed $1\frac{1}{4}$ lb., and the 40 and 50 year old classes show a steep decline in yield from the 30 year old class. A tree 30 years old on Brasso Clay appears to be older physiologically than one 70 years old on Chocolate, Brasso Sand, or Alluvial soil. Thus, on Brasso Clay we are faced with a diminishing number of trees, a falling yield as the trees get older, and the supreme difficulty of establishing young supplies.

Comparison of Chocolate, Brasso Sand—Alluvium and Brasso Clay Estates.

The relative merit of the different soils is well illustrated in the next diagram. The upper line represents a seven yearly moving average of yields in bags per 1,000 pickets of an estate consisting entirely of Chocolate soil. The middle line shows the yields of an estate comprised of Brasso Sand and Alluvium, and the lower line one entirely on Brasso Clay. You will note that the shape of the curves is similar. Each shows a rapid increase in yield in the first few years, marking the influence of young fields rising to their maximum yields. This period is succeeded by one in which yields remain stationary at their highest level. Then in each case there is a rapid and continuous decline in yields caused by the depressing factors associated with age, and accentuated by reduced expenditure on cultivation. You will recall that the Brasso Clay cultivation is much younger than that on Chocolate, Brasso Sand and Alluvium. The influence of youth is shown in the diagram by the fact that yields are rising on Brasso Clay when those on Brasso Sand—Alluvium and Chocolate are stationary. The fact that yields on Brasso Clay remain at their peak well into the depression, while the Chocolate, Brasso Sand and Alluvium are all falling rapidly, shows that some factor other than expenditure on cultivation is at work.

The most striking feature of this diagram, and one which cannot fail to impress you, is the marked difference in the yields of the good and bad soils during the entire period. The Brasso Clay estate at its very *best* never gave a yield in excess of 8 bags per 1,000 pickets. The Chocolate and the Brasso Sand and Alluvial estates at their very *worst* have never given a yield as low as 8 bags per 1,000 pickets. The Chocolate estate gave over 13 bags per 1,000 at its best, and the Brasso Sand and Alluvium 11 bags per 1,000.

This diagram presents two other points of interest. The first is, that although the Chocolate, and Brasso Sand and Alluvium, estates are declining during the same period, they are not declining at the same rate. This is partly due to the fact that fewer pickets are damaged on Brasso Sand and Alluvium than on Chocolate. The second point of interest is that both the Brasso Sand/Alluvium and the Brasso Clay now show a slight recovery in yield, whereas Chocolate has continued to decline. The final seven-year average shows, in fact, that for the very first time the Brasso Sand/Alluvium estate is giving more bags per 1,000 than the Chocolate estate. The Brasso Sand/Alluvium and Brasso Clay estates are the ones on which have been evolved the measures of rehabilitation which I shall now describe to you. Let me first summarise my opinion of the soil types under consideration. I would not accept, even as a gift, a cacao estate on Brasso Clay soil. These estates to-day represent a liability rather than an asset. I should be willing to pay a large sum for an estate on Chocolate soil, and an appreciable amount for an estate on Brasso Sand, or on Alluvium of the type described, even if I was certain that cacao prices would never rise above their present level.

The Rehabilitation of Cacao Estates.

I shall now describe the rehabilitation programme evolved by the planters in Montserrat, and being carried out on each of the four soil types. For the sake of brevity I shall confine my attention to a single field on Alluvial soil represented by this coloured diagram. This field gave an average yield of 2.7 lb. per picket, 815 lb. per acre, or 16.4 bags per 1,000 pickets in 1934-35. This, clearly, is a field of exceptional fertility. Yet, in co-operation with the manager, we judged that 19 per cent. of the pickets were incapable of ever earning their keep. They contributed only 5 per cent. of the total yield, so that they were giving only a quarter of the yield of the average picket. A few were heavy bearers of undesirably small beans, and some were badly diseased. All these were cut out and supplied. Another 13 per cent. of the pickets were young supplies and not yet in bearing. Thus 95 per cent. of the yield was obtained from 68 per cent. of the pickets. If the other 32 per cent. of the pickets, which to-day consist of young supplies, subsequently produce only the average yield of the remaining mature trees, the yield of the field will be increased by 50 per cent. But Professor Cheesman and Dr. Pound promise us supplies capable of yielding at the rate of 1 ton of cacao per acre, or over 7 lb. per picket.

Here, however, a word of warning is desirable. Some of us have hitherto assumed that the speckled appearance of our diagrams, indicating good, medium and poor bearers, has been due to genetic variability. I have endeavoured to show that most of the poor bearers can be accounted for by poor soil, damage, pests, diseases, &c. The supplies which we put in, and the trees which remain, will be subject to the same vicissitudes as the present poor bearers. We must, therefore, provide conditions which will enable trees to give of their best. The old practice of supplying every blank every year is a waste of time. Each supply needs individual personal attention and this cannot be given if the supplies are scattered all over the estate. Ground shade must be provided. (Fortunately there is a market for bananas to-day, and it is quite conceivable that they may pay for the cost of rehabilitation. The cacao planter must, however, remember that cacao is the principal consideration.) The field must be properly drained. The remaining trees must be pruned on the scientific lines recommended by Dr. Briton-Jones. The young supplies should be manured.

Above all, the young cacao supplies must be protected from injury. Careless cutlassers cause untold damage in their anxiety to complete their asks. A supply severely wounded by a cutlass

is never likely to develop into a good bearing tree. Supplies should be fenced around with cassava, or some other plant or device, to prevent injury by any sharp cutting instrument. Arrondeering should be done by hand. If the soil is good, and proper precautions are taken, there should be no difficulty in making young supplies heavy bearers.

We have no right, however, to assume that the existing high bearers will remain high bearers; on the contrary, I can assure you that many of them will not. I have shown that the principal cause of poor bearing on good soils is the damage caused by falling immortelles. A large percentage of the immortelles has already disappeared, but there remain sufficient to damage most of the trees, young and old, in the field. A single immortelle on Chocolate soil is capable of damaging 16 trees. Referring to our three favourite fields we find that to every 1,000 cacao pickets, there are 49 immortelles on Chocolate, 82 on Alluvium, and 96 on Brasso Clay. If they all fell at one time and in suitable directions they would be capable of smashing almost every cacao tree in these fields! Whether the remaining immortelles should be brought down in a manner calculated to do least harm to the cultivation, or whether they should be left to fall of their own sweet will and accord, is a matter I leave you to decide.

We must, however, devise some means of preventing any immortelle we plant to-day from causing excessive damage in the future. I am indebted to Sir Edward Rosling for some pertinent information regarding a most productive cacao estate in Ceylon. There, immortelles are grown in regular rotation. When they obtain a diameter of about two feet they are removed, without occasioning much injury to the cacao trees. I understand that *Erythrina indica* is used. Specimens can be seen in Professor Cheesman's nursery. It grows rapidly from cuttings and is spineless. It therefore provides shade at an early age, and, being spineless, the labourer can climb it without inconvenience for the purpose of trimming the branches. At all events, whatever shade tree is used it should be removed before it becomes sufficiently large to cause serious damage to the cacao trees.

I therefore suggest that each cacao planter should first ascertain whether all or a part of his estate consists of poor soil. If all of it is poor I should advise him not to spend another cent of capital on it. The question he should consider is not *what* he should plant, but *whether* he should plant. The capital he has invested in his cacao trees should cause him no uneasiness; it has gone forever. He has as much chance of draining any more capital from his cacao trees, as he has of recovering Admiral Apodocca's treasure from the Gulf of Paria. His fields represent so much soil encumbered with useless lumber, and are not worth the price of Crown Land.

The planter whose soil is mixed should concentrate on the good areas. The happy individual whose soil is all good should begin with his very best fields and proceed year by year to the next best until his whole estate is rehabilitated. By then it will be time for him to begin again. On the selected fields he should mark every tree which he considers incapable of earning a profit. This work must be done during crop because one cannot be certain of distinguishing poor and good bearers out of crop. A single visit to a field during crop is insufficient to assess a good or bad bearer because some trees are early bearers and others late bearers. Two inspections should be made, one, in, say, November or December, and another in February or March. Mature trees carrying no crop, or only one or two pods, can be daubed with a blob of paint at each visit. At the end of crop the planter can ascertain the number of trees possessing two blobs of paint and cut them out up to a limit of say 20 to 25 per cent. of the total number of pickets. Drainage and pruning are two operations requiring the most careful attention. The blank spaces should be supplied with selected plants and each supply should be manured, and protected and shaded by cassava, tannias, bananas, and other suitable plants. Shade trees should be provided wherever necessary, and if some of the old giants can be brought down without doing much damage, so much the better. The planter should not attempt to rehabilitate any area unless he has sufficient money to perform all these operations. He will not obtain maximum returns by draining, pruning, or manuring, blanks and unproductive trees. The ultimate aim should be 100 per cent. heavy bearers, and, although this will never be attained, the nearer perfection the greater the profits. I believe that Trinidad is capable of producing its present crop from one-third of the present acreage.

Acknowledgments.

Finally I must express my appreciation of the generous co-operation I have always received from planters, business-men, agricultural and scientific officers, and thank my students for doing all the hard work. I have one deep regret—that my dear friend the Hon. Carl de Verteuil is not with us to-day. From him I invariably received the most friendly encouragement, criticism and advice. He was one of the finest gentlemen it has been my privilege to know, and a son of whom Trinidad has every reason to be proud. Fortunately he transmitted his youthful enthusiasm and great skill to his son Carl, and his nephew Robert, two planters of outstanding ability who have been responsible, more than anyone else, for the evolution of the measures of rehabilitation which I have described to you to-day. Nothing has impressed me more than their stout-hearted courage in the face of great adversity, and it is my earnest hope that their pioneering efforts will be rewarded by the resuscitation of the cacao industry of Trinidad.

RECENT INVESTIGATIONS ON SUGAR-CANE AND SUGAR-CANE SOILS IN ST. KITTS.—*Concluded.*

I.—PRELIMINARY RESULTS OF THE NEW EXPERIMENTAL SCHEME.—*Continued.*

By P. E. TURNER, R. E. KELSICK and G. B. GREGORY.

Optimum Use of Inorganic Manures.

Supplementary Treatment of Penmanured Soils in the Dry Areas.

Plant canes in St. Kitts are customarily treated with 20 to 30 tons of pen manure to the acre before planting and with two cwts. of sulphate of ammonia during the wet season of the following year. As a rule the pen manure is ranged in lines along the rows of old cane stumps and covered with trash. The soil between the stumps is then ploughed. It pours over the mouldboard to cover the lines of pen manure, thus forming the banks. Cross-bars of earth are made at regular intervals in the furrows. The setts are planted in the centres of the cross-holes thus formed. Alternatively, the pen manure is placed at regular intervals in the furrows and the heaps of manure are covered with earth to form the cross-bars.

Experiments have been designed to determine on the dry and wet areas whether it pays to :—

(*a*) supplement the dressing of pen manure with an early dressing of sulphate of ammonia applied six to eight weeks after planting, and

(*b*) to increase the size of the late dressing of sulphate of ammonia.

The possible advantages and disadvantages of these experimental treatments have been previously discussed (1).

Reliable results have been obtained from one of the experiments laid down on a dry area. The yield data are recorded in Table VII.

Table VII.—Effect on yield of plant canes of early and late dressings of sulphate of ammonia (dry area of the lower lands).

Estate : Buckleys.
Soil : Sandy loam. *Variety :* B.H. 10(12).
Planted : 4/11/33. *Reaped :* 17/2/35.
Total rainfall (14½ months) : 68 inches.
Layout : Two 5 × 5 Latin squares.

Sulphate of ammonia per acre.		Yield of plant canes (tons per acre).	Gain in yield.
Jan. (1934)	May (1934).		
Nil	Nil	30.70	—
Nil	2 cwts.	33.98	3.28
Nil	3 cwts.	33.84	3.14
1 cwt.	2 cwts.	31.68	0.98
1 cwt.	3 cwts.	31.33	0.63

All plots were given a basal dressing of 25 tons of pen manure to the acre, which was applied under the banks before planting. The dressing of one cwt. of sulphate of ammonia was applied shortly before the advent of the dry season. The second dressing of this manure was applied in the latter half of the dry season.

The rainfall on the experimental area during the dry season of 1934 was :—

February	....	....	1.34 inches.
March	....	....	4.57 do.
April	....	....	0.51 do.
May	....	....	1.20 do.
June	....	....	2.17 do.

Differences in yield exceeding 2.02 tons to the acre might be due to chance less than once in 100 times.

Three conclusions may be drawn from the yield data under the conditions of the experiment :—

(*a*) A dressing of sulphate of ammonia in the second half of the dry season can give rise to a significant gain in yield.

(*b*) It does not appear to pay to increase the second dressing beyond two cwts. to the acre, if inorganic nitrogen alone is included in the supplementary manurial treatment.

(*c*) A dressing of one cwt. of sulphate of ammonia can significantly depress the gain in yield which results from the later dressing.

This adverse effect on yield of early sulphate of ammonia is of interest. Field observations made it evident that the canes on the plots dressed with one cwt. shortly before the dry season of 1934 were darker green in colour and were making more satisfactory early growth than the canes on the remaining plots. It is possible that the additional nitrogen caused excessive growth at this stage and that in consequence the canes suffered more severely during the dry season. The difference in favour of the early-treated plots, however, persisted until the canes grew too tall for further observation.

The depression in gain in yield due to the early dressing of sulphate of ammonia may have been due to an unbalance in manurial treatment, and it is possible that potash should have been applied with the nitrogen. This hypothesis is being put to practical test. An early dressing of nitrogen, alone, has been shown to have a similar adverse effect in Antigua under conditions which are strongly suggestive of unbalanced manurial treatment (3).

One other experiment on the supplementary manurial treatment of penmanured soils was laid down in 1933 on a dry area, and two others on wet areas. These experiments gave negative results, probably through irregular application of pen manure to the plots.

The yield data for a similar experiment laid down in 1932 suggest that the optimum *late* supplementary dressing of sulphate of ammonia to penmanured soils of the wet areas may lie in the region of two cwts. to the acre (5).

Manurial Treatment of Unpenmanured Upper Lands.

Circumstances make it impossible to apply pen manure to the upper lands, which at present comprise at least one quarter of the total acreage under sugar-cane. One of the main problems on these areas is to find an inorganic manure which will effectively replace pen manure (1). A number of experiments have therefore been laid down to determine :—

(*a*) the total dressing of inorganic manure which on the average gives rise to maximum financial gain ;

(*b*) the proportion of nitrogen, phosphate and potash which should be present in the total dressing ;

(*c*) the optimum times of application of the nitrogen, phosphate and potash.

Two of these experiments were harvested in 1935. The results of one experiment, which was laid down on a wet area of the upper lands, is recorded in Table VIII.

Table VIII.—Effect on yield of plant canes of early dressings of nitrogen and potash and of late dressings of nitrogen on the wet areas of upper lands.

Estate : Hope. *Variety :* B.H. 10(12).
Planted : 6/2/34. *Reaped :* 27/3/35.
Total rainfall : Not available.
Layout : One 6 × 6 Latin square.

Sulphate of ammonia per acre in 1934.		Muriate of potash per acre in 1934.	Yield of cane (tons per acre).	Gains (t.p.a.)
March.	June.	March.		
Nil	2 cwts.	Nil	28.98	—
Nil	3 cwts.	Nil	32.60	3.62
2 cwts.	2 cwts.	Nil	35.65	6.67
2 cwts.	3 cwts.	Nil	35.39	6.41
2 cwts.	2 cwts.	1½ cwts.	38.17	9.19
2 cwts.	3 cwts.	1½ cwts.	39.18	10.20

In 1933 the standard manurial treatment of plant canes on the upper lands was two cwts. of sulphate of ammonia in the wet season following planting. The yield data recorded in Table VIII show that under the conditions of the experiment :—

(*a*) an increase in this late dressing of sulphate of ammonia from two cwts. to three cwts. to the acre can lead to a gain in yield of 3.62 tons of cane. This gain might be due to chance less than once in 20 times.

(*b*) the use of an early dressing of two cwts. of sulphate of ammonia to the acre, in addition to the standard late dressing, can lead to a gain in yield of 6.67 tons of cane. This gain might be due to chance far less than once in 100 times.

(*c*) the use of a dressing of one-and-a-half cwts. of muriate of potash with the early dressing of two cwts. of sulphate of ammonia, in addition to the standard late dressing of sulphate of ammonia, leads to a further gain of 2.52 tons of cane, making a total gain of 9.19 tons due to the early dressings.

(*d*) in the presence of an early dressing of two cwts. of sulphate of ammonia, no advantage appears to be derived by increasing the late dressing beyond two cwts. *if potash is not applied.*

(*e*) in the presence of early nitrogen with potash, there are indications that it may pay to increase the late dressing of sulphate of ammonia to three cwts., especially as the heavier late dressing may lead to an improved spring of ratoon canes.

It should be noted that the experimental area was planted considerably later than is customary in general practice, and that in the circumstances it was reaped somewhat early in the season. Even greater gains might have been obtained from the manurial treatments if planting had taken place at the normal time.

Some of the most valuable of the preliminary results of the experimental scheme have been obtained from this experiment. The general tenor of the yield data suggests that by appropriate use of inorganic manures :—

(*a*) *the yield of plant canes on the upper lands can be very greatly and inexpensively increased ;*

(*b*) *many low-yielding areas of the upper lands, at present abandoned to bush as uneconomic in sugar-cane, may with advantage be taken back into cultivation ;*

(*c*) *it may be possible to maintain the upper lands continuously under sugar cane without long intervals of rest before replanting.*

At present the bulk of the cane produced in St. Kitts is obtained from the lower lands which on occasion are subject to severe drought. Violent fluctuations are therefore liable to occur in the total output of the island. Except in isolated areas, the upper lands do not suffer from drought. If, as the experimental data suggest, the yield on the upper lands can be economically increased, and if the area under sugar-cane can also be extended, it should be possible not only appreciably to enlarge the total output of the island in good years but also to maintain it at a reasonably high figure in years of low rainfall on the lower lands. Such a state of affairs would mean much to the prosperity of the island as a whole. For this reason experiments on the upper lands are being given a prominent place in the new experimental scheme.

The results of a similar experiment which was laid down on a dry area of the upper land is set out in Table IX.

Table IX.—Effect on yield of plant canes of early dressings of nitrogen and potash and of late dressings of nitrogen on a dry area of the upper lands.

Estate : Bourkes. *Variety :* B.H. 10(12).
Planted : 24/12/33. *Reaped :* 26/2/35.
Total rainfall : (14 months) : 65 inches.
Layout : One 6 × 6 Latin square.

Sulphate of ammonia per acre in 1934.		Muriate of potash per acre in 1934.	Yield of cane (t.p.a.)		Gain (t.p.a.)
Feb.	May.	Feb.			
Nil	2 cwts.	Nil	33.09	32.53	—
Nil	3 cwts.	Nil	31.97		
2 cwts.	2 cwts.	Nil	34.62	34.61	2.08
2 cwts.	3 cwts.	Nil	34.59		
2 cwts.	2 cwts.	1½ cwts.	38.58	38.11	5.58
2 cwts.	3 cwts.	1½ cwts.	37.64		

The monthly rainfall on the experimental area during the first six months after planting varied between 2.2 and 4 inches.

The conditions controlling this experiment were not altogether satisfactory. The area on which the experiment was laid down was patchy. At the time of supplying, *i.e.*, shortly before the first application of manures, only 46 per cent. of the 'cane-holes' had germinated (1). It would therefore be unwise to place too great reliance on the results. In principle, however, they appear to lend confirmation to two of the main conclusions to which the data in Table VIII give rise, namely :—

(*a*) the use of an early dressing of sulphate of ammonia, in addition to the late dressing, leads to an increase in yield ;

(*b*) a further increase in yield results from a dressing of potash with the early dressing of sulphate of ammonia.

A Precautionary Manurial Experiment.

Dressings of sulphate of ammonia lead to a slow but measurable increase in soil acidity. They enable increased plant growth, and this, in turn, leads to a greater call on the reserve of phosphate and potash in the soil.

At the time when the preliminary scheme of experiments was inaugurated it seemed probable that extended use would be made of sulphate of ammonia in St. Kitts in the near future. It was therefore deemed advisable to obtain an estimate of the effect on the soil of continued applications of this manure (1). In consequence there was included in the scheme an experiment in which dressings of 5 cwts., 10 cwts. and 15 cwts. to the acre of sulphate of ammonia were applied to plant canes. It was not considered likely that the exceptionally heavy dressings would lead to financial gain. They could, however, enable an early measure of the cumulative effects of smaller and repeated dressings.

It was intended to continue this experiment over three crops, *i.e.*, plant canes and two ratoons, and then to sample the soils of the experimental area to a view of measurement of pH value and content of exchangeable lime, of available phosphate and of organic matter. Incidentally information could be obtained concerning the immediate effect on yield of plant canes and the residual effect on yield of ratoon canes of the heavy dressings.

The site on the wet areas originally selected for the experiment was found unsatisfactory and it was perforce laid down on a dry area.

The yield data for the plant canes are recorded in Table X.

Table X.—Yield data from a precautionary manurial experiment.

Estate : Cunningham (dry area).
Variety : B.H. 10 (12).
Planted : 10/2/34. *Reaped :* 4/4/35.
Layout : One 4 × 4 Latin square.

Sulphate of ammonia per acre.	Yield of plants (tons per acre).	Gain (t.p.a.)
Nil ..	16.04	—
5 cwts. ..	22.95	6.91
10 cwts. ..	21.68	5.64
15 cwts. ..	32.32	6.28

The immediate gain in yield due to treatment with sulphate of ammonia might be due to chance less than once in 100 times. No additional immediate gain results from increasing the dressings to more than 5 cwts. to the acre.

A Manurial Experiment with Molasses.

Molasses contains comparatively large quantities of nitrogen and potash, and has been used with success as a manure for sugar cane in Mauritius and Queensland.

Dressings of molasses were included in one of the manurial experiments on the lower lands of the wet areas of St. Kitts, but failed to give rise to an increase in yield of plant canes under the conditions of the experiment. The size of the dressings was—

(*a*) nil ;
(*b*) 3.15 tons to the acre (2½ pints to the cane-hole) ;
(*c*) 6.3 tons to the acre (5 pints to the cane-hole).

The dressings were applied in the cane-holes one month before planting. It is of interest that molasses used in this manner had an adverse effect on germination which increased significantly with the size of the dressing.

Conservation of Soil Moisture in the Dry Areas.

The soils of the dry areas of the lower lands in the main are fertile and deep, and are capable of giving very heavy yields of cane provided that there is ample rain. In general these heavy yields are not obtained because soil moisture is limiting during prolonged periods. One of the most important questions on these areas, therefore, is the problem of conserving soil moisture.

Two methods of conserving soil moisture are in common use in St. Kitts :—

(*a*) constant working of the surface of the soil (until the canes close in) to form a dust mulch ;

(*b*) generous applications of pen manure in an attempt to maintain the humus content of the soil at a high level.

Constant tillage of the surface of the soil must to some extent directly assist in the prevention of loss of moisture. Its main value, however, may lie in the control of weed growth, whereby soil moisture is indirectly conserved.

It is open to doubt (2) whether dressings of pen manure appreciably increase for any length of time the capacity of the soil to retain moisture under the conditions which obtain in the cane field. Pen manure is applied to the soil only at lengthy intervals, normally once in three or four years. Even if amounts as large as 30 tons are added to the acre the weight of the dressing of organic matter is small in comparison with the weight of an acre-foot of soil. As the pen manure decomposes it diminishes very greatly in bulk. Ultimately (and on the light, open soils of St. Kitts the time is very short) all that remains is a thin stain of humus covering the soil particles. This stain retains water, but the amount of water it can absorb is limited by its small bulk. Further, it is not generally recognised that the humus content of sugar cane soils is determined primarily by the 'climatic' conditions which obtain in the cane field, rather than by the amount of humus-forming material which may be added. Under these conditions the natural humus content of the soil is low. To maintain the humus level above its equilibrium value for the purpose of moisture conservation, or the improvement of soil tilth, appears financially impossible at the present market price of sugar, unless exceptional circumstances obtain.

Comparatively large quantities of megasse are available without cost to the plantations in St. Kitts. The megasse is used as bedding in the cattle pens, and consequently as the raw material of pen manure. If the megasse were not transported to the field *via* the pens and buried as manure, but applied direct to the soil surface, it would retain its bulk for a much longer period. Its main purpose would then not be to absorb moisture, but to form a blanket to protect the soil from rapid loss of moisture. It may be argued that the manurial value of the megasse is reduced if it is used as a soil cover, rather than for the preparation of pen manure. It should be remembered, however, that the major factor limiting yields in the dry areas of St. Kitts is lack of adequate moisture. If it is found possible to conserve additional moisture by the use of megasse as a mulch, nitrogen, phosphate and potash can always be added to the soil in inorganic form.

The successive effects of a continuous spell of dry weather on sugar cane may broadly be divided into three phases :—

(*a*) diminution in rate of growth,
(*b*) stagnation in growth, and
(*c*) a definite set-back in growth.

During the first two phases the plant may recover without great loss. During the third phase the plant is seriously harmed ; it never fully recovers and the ultimate yield is very considerably reduced. There can be little doubt that diminution in rate of growth and even stagnation in growth are inevitable on open, porous soils during prolonged dry weather, whether or not a vegetable mulch is used. If by means of a mulch, however, the first two phases can be extended, and the third phase thereby eliminated or very much shortened, it is probable that the cost of applying the mulch might be well repaid.

A vegetable mulch may serve other purposes besides assisting to conserve soil moisture. It can minimise fluctuations in soil temperature. The top few inches of soil may rise to a surprisingly high temperature through direct exposure to the sun before the growing canes close in. High soil temperatures can impair the efficiency of the root system and restrict growth. Even in the height of the dry season, soil under a vegetable mulch can remain cool and moist. A mulch can also smother weed growth and thereby considerably reduce expenditure on weeding. Under Antiguan conditions it has been shown that the saving in cost of weeding can more than pay for the cost of mulching with trash (3).

Preliminary information concerning the use of megasse as a mulch is at present available from four experiments, two of which were laid down on plant canes and two on ratoons. In the experiments on plant canes two problems in relation to yield were under examination :—

(*a*) the relative efficiency of mulches two inches and three inches in thickness ;
(*b*) the comparative effect of spreading the mulch between every row of cane and between alternate rows.

A mulch two inches in thickness and spread between every row would require about 20 tons of megasse to the acre, an amount rather less than the standard dressing of pen manure.

Table XI.—Effect in dry areas of mulching with megasse on yield of plant canes.

Estate :	West Farm.	College.
Variety :	S.C. 12/4.	S.C. 12/4.
Planted :	18/11/33.	20/2/34.
Megasse applied :	21/2/34.	2/3/34.
Reaped :	20/3/35.	15/5/35.
Total rainfall :	77 inches (16 months).	51 inches (14¾ months).

Layout : Two 5 × 5 Latin squares at each site.

Treatment with megasse.	Yield of cane (t.p.a.)		Gain in yield (tons per acre).		
	West Farm.	College.	West Farm.	College.	Average.
Nil	25.31	29.53	—	—	—
2-inch mulch, alternate rows	25.13	30.70	−0.18	1.17	0.50
3-inch mulch, alternate rows	26.52	30.11	+1.21	0.58	0.89
2-inch mulch, every row ..	27.64	32.14	+2.33	2.61	2.47
3-inch mulch, every row ..	27.04	32.11	+1.73	2.58	2.15

The rainfall on the two estates during the dry season of 1934 was :—

Month.		*West Farm Estate.*	*College Estate.*
February	....	3.30 inches	0.65 inches
March	....	4.13 do.	3.70 do.
April	....	0.59 do.	0.05 do.
May	....	1.40 do.	1.10 do.
June	....	2.19 do.	1.65 do.

It is doubtful whether the increase in yield due to mulching with megasse in these experiments can be regarded as characteristic of the benefits to be derived from the operation. To obtain maximum results on open, porous soils with plant canes it is probable that the mulch should be applied shortly before the end of the wet season, *i.e.*, when the soil is saturated with water, and to plants which have begun to bunch. In the experiment at West Farm Estate the mulch was not applied until a month after the dry season had set in. At College Estate the rainfall for the month immediately before mulching was only 0.65 inches, and the megasse was added to very dry soil. It was placed on recently made banks within a fortnight after planting. In consequence the mulch slipped into the furrows leaving an appreciable proportion of the soil uncovered, and tended to smother the germinating plants.

In spite of these drawbacks, however, it is of importance to note that mulching resulted in a significant average increase in yield in each experiment, a result which augurs well for the possibilities of the operation when appropriately performed. It may further be shown that mulching between every row gives a significantly greater increase in yield than mulching between alternate rows, under the conditions of both experiments. There appears to be nothing to choose in either experiment between the efficacy of a two-inch mulch and of a three-inch mulch of megasse as far as yield is concerned. A two-inch blanket of megasse, however, may not be sufficiently thick completely to smother weed growth.

The effect on yield of plant canes of a mulch of megasse under the conditions which obtain in Trinidad (8), and of a mulch of trash under the conditions which obtain in Antigua (3) and Barbados (9) have been recorded elsewhere.

The factory begins to release supplies of megasse to the estates towards the end of February, as a rule. If the megasse is to be used as a mulch for plant canes it is necessary to accumulate and store it at the railway sidings of the estates until the end of the wet season. Storage, which would take place in the open, presents no special difficulties and involves no additional expenditure. The megasse would be applied to the field in the latter half of December or early in January, *i.e.*, at a time when planting operations have been completed and when there is insufficient work in the field to keep the labour employed (1). Storage of megasse until the end of the wet season, however, incurs loss of time in its use. For this reason it has been considered worth while to obtain a measure of its value as a mulch on ratoon canes, to which it might usefully be applied as early as March.

Two experiments on ratoon canes have been laid down. In all plots of both experiments the trash was ranged between alternate rows of stools, and the inter-rows thus uncovered were cultivated according to local practice. In some plots the bare, cultivated inter-rows were mulched with megasse. Certain plots were dressed with sulphate of ammonia to gauge the effect of the mulch on the gain in yield which results from use of nitrogen. The yield data obtained are set out in Table XII.

Table XII.—Effect on yield of first ratoons of mulching with megasse in the presence and absence of sulphate of ammonia.

Estate :	West Farm.	Douglas.
Variety :	B.H. 10(12).	S.C. 12/4.
Reaped as plants :	12/3/34.	19/3/34.
S/A applied :	28/3/34 and 13/6/34.	30/3/34 and 14/6/34.
Megasse applied :	4/4/34.	4/4/34.
Reaped as ratoons :	19/4/35.	21/5/35.
Rainfall :	53 inches (13¼ months).	53 inches (14 months).

Layout : Three 4 × 4 Latin squares at each site.

Experimental treatments		Yield of cane (t.p.a.)		Gain due to mulch.	
Megasse.	S/A p.a.	West Farm.	Douglas.	West Farm.	Douglas.
Nil ..	Nil	17.61	15.15	—	—
3-inch mulch	Nil	16.39	16.06	−1.22	+0.91
Nil ..	4 cwts.	28.93	21.19	—	—
3-inch mulch	4 cwts.	29.27	24.14	+0.34	+2.95

In both experiments the sulphate of ammonia was applied in two dressings of 2 cwts.

In the experiment at Douglas Estate the average gain in yield of 1.93 tons of cane to the acre, due to mulching, might be due to chance less than once in 100 times. The gain in yield due to mulching in the presence of sulphate of ammonia is 2.04 tons greater than in the absence of this manure. The average gain in yield of 7.06 tons of cane due to sulphate of ammonia might be due to chance far less than once in 100 times. The interaction of the mulch with sulphate of ammonia is statistically significant. *It seems, therefore, that the ratoon canes cannot make full use of the soil moisture conserved by the mulch unless adequate nitrogen is added.* An interaction of a mulch of trash with sulphate of ammonia, similar in effect but probably different in cause, has been obtained in Antigua (3).

In the experiment at West Farm Estate the average gain in yield due to mulching is negligible. The average gain of 12.10 tons of cane, due to sulphate of ammonia, might be due to chance far less than once in 100 times. The gain due to the manure is 1.56 tons of cane greater in the presence than in the absence of the mulch, but in this experiment the interaction cannot be established as statistically significant.

The mulch was applied to the plots at Douglas Estate 16 days after the plant canes were reaped, and to the plots at West Farm Estate 23 days afterwards. Well-grown cane can act as an effective cover which protects the soil from direct exposure to the sun and wind and which prevents rapid loss of moisture from the soil. As soon as the crop is harvested the soil quickly begins to dry out. The more satisfactory results given by the mulch in the experiment at College Estate, and the interaction of the mulch with applied nitrogen, may be due to the application of the megasse with less delay than in the experiment at West Farm Estate. Greater gains might have been obtained in both experiments if the interval between reaping and mulching had been shorter.

If mulching of ratoon canes is to be financially successful it appears essential to carry out the operation as soon as possible after reaping the previous crop.

In the experiment at West Farm Estate the megasse showed little sign of decomposition, and lay thick on the plots, at the time of harvesting the first ratoons.

Summary.

There are recorded in this paper a preliminary series of results obtained from a scheme of field experiments in St. Kitts under the auspices of the Sugar-Cane Investigation Committee in 1933. The more important conclusions to which the yield data give rise under the conditions which obtained are summarised below.

A classification of the sugar areas of the island is included in the paper.

Varieties.—Provided that B. 2935 is proved to ratoon satisfactorily it is likely to replace the standard variety S.C. 12/4 on the dry areas of the lower lands for reaping early in the crop season. P.O.J. 2878 gave promising results as a variety for late reaping in an experiment on these areas.

On the wet areas of the lower lands the highest average yield of cane was given by the variety B.H. 10(12) and the highest average yield of sugar by B.H. 10(12) and B. 726.

Methods of Preparatory Cultivation.—Close ploughing *with cattle* gave rise to no greater yield of plant canes than the standard method of preparatory tillage on the dry and wet areas of the *lower lands.*

Optimum Use of Lime on Acid Soils.—Slaked lime (locally burnt) gave rise to an immediate gain in yield of 2½ to 5½ tons of cane to the acre, according to the size of the dressing on a wet area of the upper lands.

Methods of Planting.—Close planting in the row led to a serious reduction in yield on a very dry area. No gain in yield resulted from close planting in the row on a moderately wet area.

Supplementary Treatment of Penmanured Soils. On the dry areas it may not pay to apply a late dressing of sulphate of ammonia larger than two cwts. to the acre. An early, light dressing of nitrogen, *applied alone,* can depress the gain in yield resulting from the late dressing.

Manurial Treatment of Unpenmanured, Upper Lands.—An early dressing of sulphate of ammonia, in addition to the customary late dressing, can lead to a very substantial increase in yield of plant canes. Use of potash with the early nitrogen can lead to a further paying gain in yield.

The general tenor of the experimental results on the upper lands suggests that by greater use of inorganic manures :—

(*a*) yield of plant canes can be largely and inexpensively increased ;
(*b*) low-yielding areas at present uneconomic in sugar cane can be taken back into cultivation with advantage ;
(*c*) it may be possible to dispense with the customary long intervals of rest before replanting.

A more intensive and extensive development of sugar-cane cultivation on the well-watered upper lands would serve to mitigate the serious effects on the prosperity of the island, as a whole, which result from periodic droughts on the lower lands.

Conservation of Moisture on the Dry Areas.—Experiments are under way to determine whether greater gain would result from the use of megasse as a mulching material to conserve soil moisture rather than as the raw material of pen manure.

Yield of plant canes.—It appears that there is nothing to choose between a mulch of megasse of two inches and of three inches thickness. It is probable that greater benefit is derived by applying the mulch between every row of cane rather than between alternate rows.

Yield of ratoons :—It seems essential to apply the megasse on the soil with minimum delay after reaping the previous crop. Adequate dressings of nitrogen then appear necessary to enable full use of the moisture conserved.

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CO-OPERATION IN INDIA AND AFRICA.*

At a Joint Meeting of the Planters' Group and Empire Social Services' Group of the Royal Empire Society held on January, 16th, Mr. W. G. Freeman, F.L.S., in the Chair, Mr. C. F. Strickland, C.I.E. (I.C.S. Retired) referred to the transformation which was now being made in India, and to a lesser extent in Africa and China, through the co-operative movement generally. His principal thesis was, however, that the larger producer and the more prosperous and educated person required especially in Asia and in Africa, a different manner of approach and a different form of co-operative organisation from the small producer and the less prosperous and educated person. Co-operation in Asia and in Africa was concerned primarily with agriculturists, but urban co-operation should not be neglected even in these countries. Marketing and supply societies—for planters and large scale farmers—could usefully extend over a larger area than those of petty cultivators. Similarly, credit could be granted by financial institutions to individuals operating on a large scale, but could only be allowed to poorer persons if they were united in co-operative groups with a joint responsibility. In the latter case it was wise to base the credit (co-operative credit) of the group on a foundation of thrift.

Indigenous races in Asia and Africa did not make a clear distinction between economic and social—or even religious—matters. There were consequently fields open to co-operation amongst such races which would not normally be so handled in Europe and America. The co-operative societies for arbitration, education, health and " better living " in its various aspects would lie within this field, and had been effectively developed in several parts of India, as also in Jugoslavia ; they were now protected even in Tropical Africa.

He was an unrepentant believer in the compulsion of a minority of producers, wherever a large majority were already organised in a co-operative body, and he preferred this method to that of the British Marketing Acts.

Small farmers and persons of modest education would require a co-operative law granting to the supervising authority fuller power than was necessary for planters or big farmers. The law might be divided into two parts or two laws might be passed. Supervision by a competent staff of trained co-operative organisers was useful in either case, its degree varying with the enlightenment and standard of the co-operators themselves. If the movement was to include every kind of co-operative society, such as the social type previously mentioned, the organisers should be men of wide co-operative experience but not necessarily agricultural experts. A careful audit of every Society, whatever the quality of its members, was always essential.

Mr. Strickland illustrated his remarks by instances drawn from a number of Asiatic and African countries, and travelling even further afield.

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THE GROWTH AND UTILISATION OF FODDER GRASSES IN TRINIDAD.

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[*The effect of varying the cutting rotation on a soilage crop of Elephant Grass has been described in "Tropical Agriculture" XI, pp. 5-6. This fodder grass research has been continued for another year, and the following paper is a summary of the practical aspects of the results. More detailed accounts will be found in "The Journal of Agricultural Science" XXV, p. 369-396, July, 1935, and in "The Empire Journal of Experimental Agriculture" IV, p. 6-16, January, 1936.*]

I.—The Experiment.

The results of the 1932 experiment with Elephant Grass were sufficiently interesting to merit a more comprehensive field trial in 1933-34, in which several varieties of fodder grass and appropriate modifications in the cutting rotations were included. The treatments selected were as follows :—

Cutting Rotations.

Series A.—Plots harvested every 45 days or 8 times per year.

Series B.—Plots harvested every 90 days or 4 times per year.

Series C.—Plots harvested every 120 days or 3 times per year.

Series D.—Plots harvested every 160 days or twice per year.

Varieties.

Elephant Grass (*Pennisetum purpureum*).

Guatemala Grass (*Tripsacum laxum*).

Uba Cane (*Saccharum sinense* var. *Uba.*)

Using a 4×4 Latin Square lay-out, the cutting rotations were arranged on main plot units, each of which was subdivided into three similar sub-plots on which the three varieties were planted. The arrangement of the varieties within the sub-plots of any one main plot was randomised, so that the lay-out was such as to permit of a valid statistical interpretation of the yield data. Propagation was from single tiller root divisions of old stools, a 3′×1½′ spacing being adopted throughout. The crop was given three months to establish itself. It was supplied twice during this period, so that by 9th August, 1933, when the actual experiment commenced, the percentage stand on all plots was over 95 per cent. The main plot size was 54′×63′, giving a total crop area of 1.3 acres.

The soil on the College Farm on which the experiment was carried out has been described as a sandy loam, acidic in character and of medium low nutrient status. As the cropping rotation used on the farm is continuous, and the land gets no rest period in which to recuperate, it is necessary to manure at fairly frequent intervals in order to maintain even a moderate degree of fertility. This is especially true when the land is put down to a perennial fodder crop which may yield from 10-20 tons dry matter per acre per annum representing a considerable drain on the soil nutrients. In consequence the whole experimental area was at planting time given a dressing at the rate of 15 tons farmyard manure+2 cwts. sulphate of ammonia per acre. In addition, 300 lb. blood meal and 70 lb. muriate of potash per acre were applied after each harvest of Series B, *i.e.*, at three-monthly intervals. It was hoped that by using such frequent light dressings of an organic fertiliser, the nutrient status of the soil would be maintained and, at the same time, excessive reflection of the manurial treatment on the yield and composition of the produce at any one harvest would be avoided.

For each harvest of each plot, representative random samples were taken to supply material for chemical analysis. For every cutting, the produce selected for analysis from all the plots of any one treatment series was bulked, chaffed, and duplicate samples of one kilogram each were sent to the Chemistry Department of the College where, by kind favour of Professor Hardy, they were analysed. The analytical data are of fundamental importance in arriving at an accurate interpretation of the results, and it is with pleasure that the writer acknowledges his indebtedness to the Staff of the Chemistry Department—Professor Hardy, Dr. Duthie and Mr. Rodriguez—for their assistance and willing co-operation in this direction.

II.—Yield Data.

The duration of the experiment was one year and a summary of the total yields of each treatment over this twelve-month period is given in Table I.

The herbage and dry matter means show the same general trend, an increase in yield from Series A to D and from Elephant Grass to Uba Cane. Statistics applied to the full data in each case gave practically identical conclusions, and to avoid tedious repetition, discussion has been limited to the dry matter yields, which for a soilage crop give the better estimate of the relative values of the different treatments. Statistical analysis demonstrates a significant difference between the variety means for all rotations, between the rotation means for all varieties, and also between the variety yields for any one rotation or *vice versa*. This proves, for each of the varieties separately :—

(i) that cutting as frequently as every 1½ months depresses the yield ;

(ii) that there is no yield difference between the three and four month cutting rotations (Series B and C) ;

(iii) that a six months' cutting rotation (Series D) increases the yield of Guatemala Grass and Uba Cane, but decreases the yield of Elephant Grass, when compared with the Series B and C data.

Table I.

YIELDS IN TONS PER ACRE.

	Green Herbage.				Variety Mean.	Mean as a percentage of Uba.	Dry Matter.				Variety Mean.	Mean as a Percentage of Uba.
	Cutting Series.						Cutting Series.					
	A.	B.	C.	D.			A.	B.	C.	D.		
Elephant Grass ..	14.7	19.9	16.6	12.4	15.9	47.7	2.05	4.27	4.17	2.88	3.34	48.3
Guatemala Grass	21.2	29.0	27.2	32.9	27.6	82.7	3.69	5.75	5.68	7.34	5.62	81.2
Uba Cane ..	18.0	34.1	34.9	46.4	33.4	100.0	3.15	6.39	7.10	11.10	6.93	100.0
Cutting Rotation Mean ..	18.0	27.7	26.2	30.6	..	..	2.96	5.47	5.65	7.11	..	..
Mean as a Percentage of Series D. ..	58.8	90.6	85.6	100.0	..	..	41.7	77.0	79.5	100.0	..	..

Then, comparing the varieties, the Elephant Grass yields less than the other two fodders for each and all of the four rotations used. For rotations up to four months, in which the herbage is still immature, the Uba Cane and Guatemala Grass give equivalent yields. On a six months' rotation, the Uba shoots ahead of the Guatemala Grass and shows a much higher tonnage, due largely to the rapid development of the heavy sugar-canes. The low yield of Elephant Grass is attributed to a severe attack of a *Helminthosporium* spp. fungus on the foliage of this grass. This fungus made its appearance some six weeks after planting, and the infection continued and increased in intensity throughout the experimental period. Attempts to control it were entirely non-efficacious. This severe parasitism of the Elephant Grass appears to be more or less confined to Trinidad, and to be sporadic in nature, occurring only in certain years. The very low yields recorded above prove that in localities where this fungus is known to be endemic, it is not advisable to plant Elephant Grass as a perennial fodder.

III.—Chemical Composition.

While these figures for gross yields are both interesting and conclusive, they require considerable amplification before a good soiling technique can be evolved. It is essential to know at what stage the crop should be harvested to give the maximum yield of digestible nutrient per acre as distinct from mere bulk produce. Previous research has shown that the stage of maturity at which the herbage is cut will have a very marked influence on its chemical composition. For example, the dry matter percentages alone show values ranging from 17 to 26 depending on the particular cutting rotation adopted. The older the herbage the lower its moisture content. This represents a variation of some ±20 per cent. of the average. A similar trend is noticeable in the protein values expressed as a percentage of the dry matter as evidenced by the following average data.

AVERAGE CRUDE PROTEIN PERCENTAGE IN THE DRY MATTER.

	Cutting Series.				Variety Mean.
	A.	B.	C.	D.	
Elephant Grass ..	10.03	7.19	6.93	6.12	7.57
Guatemala Grass ..	8.43	6.50	4.32	3.81	5.76
Uba Cane ..	7.62	5.18	4.18	2.86	4.96
Cutting Rotation Mean	8.69	6.29	5.14	4.26	

Of the three fodders, the Elephant Grass is apparently the most nutritious. This is possibly due, in part, to the *Helminthosporium* fungus which lowered the productivity and led to the cutting of less mature herbage at each harvesting date. The Guatemala Grass is a little more nutritious than the Uba Cane, particularly in Series D, after the Uba has begun to "cane". Of all the proximate constituents of stock fodders, the protein is the most important item from both the nutritional and the economic aspects. It is apparent from these recorded protein percentages that the more mature produce has a distinctly lower food value per unit, and it is questionable if the high yields of Series D will compensate for the decrease in the percentage of the valuable food constituents and the increase in the crude fibre and non-digestible elements. As a test of this the analytical data have been used to calculate the protein yields for each plot and each harvest and the results are summarised in the table following.

IV.—Yield of Crude Protein in lb. per acre per annum.

	Cutting Series.				Variety Mean.
	A.	B.	C.	D.	
Elephant Grass ..	452	604	574	322	488
Guatemala Grass ..	680	806	527	584	649
Uba Cane ..	535	695	677	628	634
Cutting Rotation Mean	556	701	593	511	

It is strikingly evident that the produce from the Series B plots has given for all three species the greatest yield of protein per acre. Thus, if it is assumed that the crude protein is a fair index of relative food values, it would appear that, while a cutting rotation exceeding three months will generally increase the bulk yields of herbage and dry matter, it will lower the total nutrient return. Furthermore, the digestibility coefficient for the relatively immature type of herbage from Series B will normally be distinctly higher than that for the Series C and D produce, accentuating the differences in yield of nutrient in favour of Series B.

Comparing the three varieties, the extra protein content of the Elephant Grass is not sufficiently great to compensate for the low bulk yield. On the other hand, although the Guatemala Grass is inferior to the Uba cane in total tonnage of herbage and dry matter, its average protein return for all series is quite as good as that of Uba; and if a relatively severe cutting rotation is adopted, as in Series A and B, it shows a distinctly better protein yield possibly as a result of its more leafy habit of growth.

V.—Seasonal Variation.

It has been shown that the stage at which the crop is cut not only affects the yields but also the composition of the produce. There is still another factor that has a considerable influence on both yield and composition, and that is the season of the year. In the humid tropics with an equable climate the only seasonal factor that shows any great variation from month to month is the rainfall, and the productivity of the perennial fodders is closely and positively correlated with the rainfall distribution. In this experiment the correlation coefficient between number of inches of rain and yield of produce in Series A was calculated and gave values of +.987 and +.802 for Guatemala Grass and Uba Cane respectively. Both these values are definitely significant. In the wet months the yields of herbage increase. The dry matter percentage on the other hand, shows a negative correlation with rainfall, which helps to compensate for the decrease in yield of herbage following on a prolonged spell of dry weather. If the rations are being issued on a green weight basis, it is possible, in the dry season, to decrease the quantity fed per head by some ten per cent. and yet supply the same total nutrient.

In the original experiment with Elephant Grass, a marked negative correlation between protein percentage and rainfall was noted. In periods of high productivity, the protein percentage falls, whereas in the low rainfall months it tends to rise. The data from the present experiment did not show a similar negative correlation between protein percentage and rainfall incidence. The reason of this apparent reversal of the previous year's results is that the second season was abnormally dry giving rise to drought conditions as contrasted with the usual dry weather ones in which the soil moisture content is never unduly depleted. It is an accepted fact that under drought or semi-drought conditions the protein percentage of fodder crops generally falls, and that is what has occurred here. Hence, in seasons of very heavy rainfall and high productivity, the protein percentage will be relatively low; with a decrease in productivity associated with a drop in monthly precipitation or with periods of light rainfall a rise in protein content may be anticipated. If, however, the decrease in precipitation is so marked as to develop semi-drought conditions a fall in protein percentage will again become inevitable.

VI.—Field Observations.

In order to amplify and confirm the information accruing from the yield data, careful notes were kept regarding the growth of the different species under the varying treatments. In addition, observation plots were marked out on an adjacent piece of land and on these, six different fodder crops were planted including the three species used in the main experiment and also the following three grasses which show some promise as soilage crops for Trinidad:

Para Grass (*Panicum barbinode*).
Guinea Grass (*Panicum maximum*).
Coimbatore Cane (*Saccharum sinense* var. Co. 213).

The observation plots were subdivided to small sub-units on which the following treatments were superimposed:—

Four cutting Rotations, A, B, C and D (as in the main experiment).

Three Heights of Cutting:
Shaved to ground level.
4 ins. to 6 ins. above ground level.
10 ins. to 12 ins. above ground level.

Two Spacings—2 ft. by 1½ ft. and 3 ft. by 2 ft.

These plots were not designed as a yield trial but were used to obtain some idea, merely from observation, of the reactions of the different species to the varying treatments. The resulting data co-ordinated with that accruing from the field notes in the main experiment, have brought to light some facts of considerable interest, a summary of which is appended.

(*a*) *Weed Control.*—With all perennial fodders, it is necessary to consider not only the potential nutritive value per acre per annum, but also the amount of cultivation required to maintain this yield level for a reasonable period of years. For the fodder crops under test the cultivation required is closely correlated with the amount of weed growth appearing in a given time. The ideal soilage crop is one in which the natural habit of growth of the crop itself is such as to inhibit the development of extraneous vegetation. As regards weed control, the species can be classified as follows :—

Para Grass Guatemala Grass	Very good. Weeds practically precluded, except in periods of drought when even weed development is at a minimum.
Guinea Grass Co 213 Cane	Satisfactory.
Uba Cane Elephant Grass	Poor.

The severity of the cutting rotation has also considerable influence on the weed incidence, the more lenient it is, the less the weed growth. Thus for all species under observation, Series A plots showed a relatively thick weed growth, while those in Series D were practically weed free. In the B and C Series it was easy to differentiate species that were good weed eradicators from those that were not. Plots of the first four grasses mentioned above kept practically weed free, while the Uba and Elephant Grass showed a thick growth after each harvest. The close spaced plots were, on the whole, cleaner than the wide spaced ones, and certainly, if frequent harvests at short intervals are required the closer spacing is to be recommended.

(*b*) *Regeneration.*—The ratoon crop can develop in two distinct ways, (i) from terminal sprouts, and/or (ii) from lateral buds. Terminal sprouting occurs where the growing point at any harvest remains on the stool, and by continued development gives rise to the new shoots, the first few leaves of each being truncated as a result of the previous harvest. As harvesting merely implies the removal of so much of the foliage, without any growth check, this method results in rapid ratooning and an early ground cover. Lateral sprouting occurs when the growing points are removed in the cut herbage, and tillering takes place by development of the dormant buds at the base of the old shoots. In this case, there is a definite growth check as it takes three to four days before there is visible evidence of new growth. On the other hand, on any one tiller, it is possible for several buds to develop simultaneously, so that lateral development is associated with somewhat slower ratooning but with an increase in the number of new shoots ultimately produced. The best ratoon crop will be obtained when both methods of sprouting are found on any one stool, terminal sprouting to provide an early ground cover, and bud development to increase the number of tillers ultimately produced and so give greater productivity. The particular method of regeneration used by the plant is closely correlated with the cutting rotation adopted. It is obvious that with semi-mature herbage, the growing tips are practically all removed at harvest and lateral development is the normal procedure. With frequent harvests and young herbage, the reverse is normally true. Between these two extremes, there is a much greater possibility of obtaining both systems of regeneration simultaneously, and this, on the average, is what actually did happen on the plots of the B and C Series in the experiment.

(*c*) *Height of Cutting.*—The three different heights of cutting used on the observation plots—shaving, four to six inches and ten to twelve inches above ground level—demonstrated first of all that shaving is definitely deleterious to the health of the plant, resulting in a small stool, with poor root development and low productivity. As an additional proof of this, periodic counts of stool mortality were taken, and a significantly greater percentage mortality was shown to occur on the shaved plots and on those of Series A where a severe cutting rotation had been used. High cutting, on the other hand, is associated with terminal sprouting, rapid ratooning and quicker maturing, as evidenced by the marked "stepped" effect in the height of the produce on adjoining plots in accordance with the height of cutting—high, medium or low—at the previous harvest. High cutting, within reason, has therefore some definite advantages. Moreover it facilitates harvesting as the tough fibrous butts of the older herbage make for difficult mowing. The brushing cutlass is not really suitable for cutting produce higher than one foot above ground level, and the following technique is suggested. At the first harvest, cut the produce three to four inches above ground. At each succeeding one, cut one to two inches above the previous level so as to strike through the young fresh tissue rather than the fibrous butt. When the stumps have reached approximately one foot in length, take the next harvest back to the original 3-inch level and repeat the process. This technique, which includes the occasional removal of the hard woody butts will encourage tillering, simplify harvesting, and possibly reduce the pest incidence by eradicating old and dead tissue in which both insects and fungi are apt to proliferate.

(*d*) *Flowering.*—Flowering, in perennial fodder crops, is an undesirable feature, as it is generally associated with a transference of nutriment to the reproductive parts of the plant, a loss in digestibility in the existing herbage and a much slower development of new foliage. Any tendency towards premature flowering is to be deprecated. The 1933-34 season in general, and the prolonged dry spell in particular were such as to encourage flowering and show up differences between the species in this direction. With the exception of the two canes, a few flowers were noted on all

the fodders at some time during the season, generally on the Series D plots where there was an interval of six months between harvests. The only real offender was the Guinea Grass, in which reproduction resulted in the development of long fibrous flowering shoots, was practically continuous and was accompanied by a yellowing and drying up of the leaves. Inflorescences were found in some cases on plots less than six weeks after harvest. From this aspect, Guinea Grass is not the ideal fodder for Trinidad conditions. The Para Grass also showed fairly profuse flowering, but in its case the growth habit was not changed, the foliage production remained satisfactory, and the herbage retained its normal green and succulent character.

(*e*) *Hardiness.*—Hardiness is another feature that is of considerable importance in a perennial crop. The only serious pest that made its appearance was the *Helminthosporium* fungus on the Elephant Grass. It has already been pointed out that this makes it inadvisable to plant Elephant Grass in localities where this disease is known to have occurred in epidemic form. While all the species can be described as drought hardy, the two canes—Uba and Co. 213—were least affected, while the Para Grass and Elephant Grass were most affected by the prolonged spell of dry weather. These last two are most productive under wet, almost semi-swamp conditions, whereas in like circumstances the two canes would require good drainage before they would yield satisfactorily. During drought the Para Grass practically limits its growth to the production and extension of a few prostrate runners or stolons and gives a negligible quantity of harvestable forage. The Guinea Grass under similar circumstances continues its growth, but develops a yellow, dry unpalatable looking herbage and tends to run to flower. Of the six the Guatemala Grass probably shows least response to adverse climatic conditions, continuing to give satisfactory growth at all seasons of the year from the abnormally wet to the excessively dry.

Another feature of some interest is that young herbage stands up to dry weather conditions better than old. This is thought to be due to the smaller leaf area and reduced transpiration surface on plots not covered with a heavy growth of herbage. Thus, on recently mown plots, the root system has a better chance of coping with dry atmospheric and soil conditions. It might be advisable in dry weather to reduce the period between harvests. Where a fixed acreage is under crop this will normally occur in the natural course of events, as in the dry season, productivity is lessened and the stockman will complete his rotation cycle in a shorter time.

(*f*) *Nutritive Qualities.*—Chemical analysis of produce from the observation plots showed certain differences in the average composition of the different fodders. The usual increase in dry matter percentage and fall in protein percentage from Series A to D were present in all samples. On the average, the Guinea Grass has a dry matter percentage some three per cent. higher than that of the other fodders. For this reason, it is sometimes preferred to the more succulent types as roughage for horses. Young herbage of Elephant Grass has a two to three per cent. higher moisture content than the other species. The average dry matter percentage for produce on a three months rotation was 18 per cent.

In protein, the Para Grass is exceptionally rich followed by Elephant Grass. The Uba and Co. 213 canes are relatively poor. The average values recorded were :—

Para Grass	....7.15	Per cent. Protein in the Dry Matter.	
Elephant Grass	....6.62	do.	do.
Guinea Grass	....5.85	do.	do.
Guatemala Grass	5.26	do.	do.
Co. 213 Cane	4.90	do.	do.
Uba Cane	4.61	do.	do.

Para Grass is in consequence particularly valued as a roughage for dairy stock, where it is said to increase both the yield and the quality of the milk.

VII.—Discussion.

It is rarely advisable after relatively limited trials on one soil type to make too definite recommendations regarding the application of results to field practice. On the other hand, it must be admitted that, in this particular aspect of crop utilisation in the Tropics, our scientific knowledge in the past has been particularly meagre, and that existing practices are entirely haphazard and not based on any proven principles of crop growth. Furthermore, the accrued data do not introduce any revolutionary ideas, and in consequence the following provisional suggestions are mooted in the hope that they may be of temporary help to the farmer pending further and more thorough research.

Of the six species tested, the Guatemala Grass appears to be the best soilage crop under Trinidad conditions. It has all the essential features of a good perennial fooder, yield, persistency, fair nutritive quality, and palatability. It is best utilised on approximately a three-month cutting rotation, when the height of the herbage will be from 3½ feet to 5½ feet high, depending on the season of the year, dry or wet. It ratoons quickly on this rotation both by terminal and bud development, and it forms an effective weed smother. In nutritive value, the produce is about equivalent to a rather low-grade sample of meadow hay in Europe, and chemical analysis indicates that some 60 lb. of herbage per day should provide a maintenance ration for a 1,000 lb Zebu ox. It should preferably be planted early in the wet season—May to July—when the humid soil conditions facilitate propagation and encourage rapid establishment. The best planting

material to use is two to three tiller root divisions from old stools. Some intercultivation during the first three to six months is advocated to keep the weed growth down, but after this, the crop should require little cultural attention. In order to maintain a high level of productivity over a number of years, periodic dressings of fertiliser, appropriate to the soil type, are essential.

These suggestions are provisional, and require some qualification. For example, of all the known perennial fodders of the humid tropics, Elephant Grass is today probably the most popular and has recently been tried out with success in many new countries. Under normal conditions, it appears to give very high yields and the experiment just completed shows that it is slightly more nutritious than the Guatemala Grass. It is only its susceptibility to the *Helminthosporium* fungus which inhibits its cultivation in Trinidad. Tests are even now being carried out on the College Farm with a strain that has shown partial resistance to this particular fungus, and if the degree of immunity is sufficiently marked, it is possible that, in future experiments, it may prove itself to be superior to the Guatemala Grass. Similarly, Para Grass is definitely very rich in protein, and has many other good factors as fair yields, palatability, hardiness, and effective smother. It has one great drawback, namely, that on arable land it forms an obnoxious and persistent weed, which spreads rapidly by runners or by small sections of the prostrate stems which root readily at the nodes. As a stock food, therefore, there is a danger that some of the grass may be swept up with the manure, and ultimately spread on to the land and give rise to a heavy crop of weeds. The theory that the nodes can pass through the digestive tract of tropical cattle and remain viable is apparently a fallacy as tested recently with the working oxen on the College Farm. The grass falling to the floor and mixed with the dung can, however, remain in the manure heap for relatively long periods extending into months and retain its viability. In fact, it is rather a difficult herbage to rot thoroughly by the ordinary processes used in activated composts. It can be composted successfully, provided certain precautions are taken of which the most important one is chaffing. One way of avoiding the risk of dissemination of the Para Grass in the manure is by utilising it on a system of rotational grazing as an alternative to soiling. This type of grazing has also been tried with success with some of the other tropical fodders as Elephant Grass. The stock are penned on any one section of the crop for only a few days at a time. They should be put in when the crop is at the stage at which it would normally be cut for soilage, say on a three months' cycle. Sufficient animals should be grazed to consume the majority of the herbage and so encourage tillering. As the time in any one pen is limited to a few days, damage to the stools by trampling is negligible, and the crop benefits by the manure from the animals. For dairy stock, it would appear to be the ideal method combining high yields and economy in utilisation.

Where the dry season is the critical time as regards fodder requirements, it is possible that a cane variety—say Co. 213—might yield better than the Guatemala Grass, as it has a deeper root system and is more resistant to drought. In these circumstances, Para Grass would be useless, but on swampy, badly drained soils in wet localities, Para and Elephant Grass will thrive and possibly be preferable to the Guatemala Grass.

This fodder grass research is being continued but has of necessity been limited up to date to the agricultural aspects of the problem. The ultimate test of any ration is its utility to the animal, and until digestibility trials become feasible, any theories put forward based on yields and chemical analysis alone must be looked upon as tentative ones, requiring further proof. One of the chief difficulties in livestock improvement in the tropics is the poor quality of the rations on which the majority of the animals are fed. The use of concentrates is the exception rather than the rule, and their staple diet is roughage in one form or another. That the stock can live and even thrive on the very low grade fodders often fed to them says much for their inherent hardiness. Their performance, whether it be milk or meat or work, is strictly limited by under nutrition. Even if the use of concentrates is ruled out on account of expense, it is generally acknowledged that the average quality of the rations can be greatly improved by a more thorough understanding, based on scientific research, of the various species of roughage, their relative importance for the different types of livestock, their starch equivalent values as determined in the laboratory, and a suitable technique as regards cultivation and utilisation. It is to be hoped that greater facilities will be forthcoming in the near future to allow this branch of agricultural research in the tropics to be brought to a parallel stage of development to that of the temperate zone, where recent progress has been both rapid and of great practical significance.

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To be obtained from the Editor, *Tropical Agriculture*, Imperial College of Tropical Agriculture, Trinidad, B.W.I.

WEST INDIAN NOTES.

(Compiled by the Advisory Department, Imperial College of Tropical Agriculture.)

The Sugar Industry.

In the northern Islands of St. Kitts and Antigua rainfall distribution was uneven in 1935, and in many areas prolonged and unfavourable dry spells were experienced. In general, the northern half of St. Kitts has produced an excellent crop, but the crop in the dry areas in the south and east is below average. The total crop of St. Kitts is however estimated at about 28,000 tons sugar. In Antigua, the crop is estimated at 18,000 to 19,000 tons sugar, the smaller figure being more likely if the present very dry conditions continue.

In St. Lucia, the 1936 crop is estimated at about 8,200 tons, compared with 7,000 tons in 1935. This estimated increase is largely the result of an improved agricultural policy, better field practices, in particular, better drainage, and of the substitution with B.H. 10(12) of inferior cane varieties.

In Barbados and Trinidad very favourable weather conditions prevailed throughout the growing season and record crops are anticipated in both Islands. The crop in the former is estimated at 120,000 to 125,000 tons, and in the latter at about 140,000 tons.

* * *

Cotton.

The third annual general meeting of the West Indian Sea Island Cotton Association was held in St. Vincent in January, 1936. A summary of the proceedings of the meeting was given in the Editorial columns of this Journal in February, 1936. The report of the meeting has subsequently been published and circulated to members of the Association.

The Association continued to adopt a policy of restriction of production, but, in view of the favourable statistical position of the industry, allocated a more liberal production quota to the respective Islands than in the past two years. The estimated production in 1936 is shown in Table I.

Table I.—Estimated Acreage and Production for 1935-36.

Island.	Acres.	Production.		
		Lint lb.	Bales of 400 lb.	Lb. per acre.
Sea Island.				
St. Vincent ..	3,000	300,000	750	100
Barbados ..	300	30,000	75	100
Montserrat	5,000	1,000,000	2,500	200
Antigua ..	600	60,000	150	100
Nevis ..	2,000	200,000	500	100
St. Kitts ..	1,000	200,000	500	200
Anguilla ..	400	26,000	65	65
Tortola, B.V.I. ..	400	60,000	150	150
Total ..	12,700	1,876,000	4,690	—
Marie Galante.				
Grenada ..	5,250	300,000	750	57
St. Vincent ..	730	41,000	102½	56
Total ..	5,980	341,000	852½	—

Table II.—Production and Export Figures for Cotton in 1934-35.

Island.	Acres.	Production, 1934-35.					Export, 1935.			
		Lint.			Bales of 400 lb.	Lb. per acre.	Lint.			Bales of 400 lb.
		Clean lb.	Stained lb.	Total lb.			Clean lb.	Stained lb.	Total lb.	
Sea Island.										
St. Vincent ..	1,464	146,091	27,644	173,735	434	119	178,372	27,087	205,459	514
Barbados ..	465	40,465	336	40,801	102	88	..	..	41,277	103
Montserrat ..	4,438	948,928	67,459	1,016,387	2,541	229	995,398	65,557	1,060,955	2,652
Antigua ..	200	32,350	600	32,950	82	165	32,350	600	32,950	82
Nevis ..	800	..	..	72,603	182	91	..	..	72,203	181
St. Kitts ..	400	92,541	9,328	101,869	255	255	..	..	106,697	267
Anguilla ..	300	..	..	26,276	66	88	..	..	27,916	70
Total ..	8,067	1,260,375	105,367	1,464,621	3,662	..	1,206,120	93,244	1,547,457	3,869
Marie Galante.										
Grenada ..	5,250	..	..	386,400	966	74	..	..	386,400	966
St. Vincent ..	652½	..	..	36,805	92	56	..	..	38,604	96½
Total ..	5,902½	..	..	423,205	1,058	..	..	..	425,004	1,062½

The area planted in Sea Island cotton in 1934-35 and picked in 1935 amounted to 8,067 acres, being about 1,700 acres more than the area recommended by the West Indian Sea Island Cotton Association for that season and approximately 2,500 acres more than the previous season. The majority of the islands planted within reasonable limits more or less than their respective allocations, but in Montserrat nearly 1,000 acres more than the allocation made by the Association were planted.

The total production of Sea Island cotton in 1935 exceeded estimates by nearly 25 per cent. and amounted to 1,465,000 lb. A record crop of a little more than 1,000,000 lb. in Montserrat was the chief cause of this increase. A very marked change in market conditions occurred during the year. Sea Island cotton was much in demand and in consequence the entire crop was rapidly sold. There were no stocks carried over at the end of the year.

Figures for production and export in 1935 are set forth in Table II.

* * *

The Fruit and Vegetable Industry.

Table III.—Bananas.

Exported during 1935 to the Canadian Banana Co.

	Trinidad.	Grenada.	St. Vincent.*	St. Lucia.	Dominica.	Total.
Nines	23,549	19,723	1,286	17,067	19,677	81,302
Eights	20,672	15,222	1,648	18,596	21,110	77,248
Sevens	21,868	16,747	2,436	20,166	22,954	84,171
Sixes	280	4,760	400	4,064	2,051	11,555
Totals	66,369	56,452	5,770	59,893	65,792	254,276
Counts	50,053	40,703	3,840	42,113	47,496	184,205
Percentage	75	72	66	70	72	72

* 1st shipment in July.

Bananas.

The banana industry continues to expand. In Table III the bananas supplied by the various Island organizations to the Canadian Banana Co. for the year 1935 are set forth.

Limes.

The Industry in Dominica in 1935.

The production of limes and lime products during 1935 was greater than in the previous year, and the exports calculated as barrels of fruit showed an increase of over 1,000 barrels. The export figures expressed in barrels of fruit totalled 28,214 in 1935 as compared with 27,093 in 1934. There was also a fairly large carry-over of lime products at the end of 1935, whereas the carry-over at the end of the previous year was negligible. Young budded lime trees planted since the destruction of the seedling lime by hurricane (the last of which was in 1930) or disease have begun to bear good crops and there is now every prospect of the production gradually increasing.

The principal lime products exported and their estimated f.o.b. values were as follows:—green limes 4,034 barrels, £6,123; raw juice 48,074 gals., £2,002; concentrated juice 3,372 gals., £184; distilled lime oil 7,127 lb., £7,443; ecuelled oil 140 lb., £186.

The Industry in St. Lucia.

The total production figure for limes and lime products was not materially different from that of the previous year. Green lime exports however increased by about 10 per cent.

Exports of green limes during the year 1935 are set forth in Table IV.

Table IV.

Exports of green limes during 1935 in Barrels.

	U.S.A.	Canada, Bermuda, U.K. and B.W.I.	Total.
Dominica ..	3,782	252	4,034
St. Lucia ..	5,112	1,507	6,619
Montserrat ..	1,711	380	2,091
St. Vincent	—	250	250
Trinidad ..	371	194	565
Total ..	10,976	2,583	13,559

Table V.—Oranges (Crates).

Island.	1934 *				1935 *			
	Bermuda.	Canada.	Elsewhere.	Total.	Bermuda.	Canada.	Elsewhere.	Total.
Dominica ..	817	3,562	5	4,384	1,279	5,355	..	6,634
St. Lucia ..	117	1	196	314	64	12	160	236
Total ..	934	3,563	201	4,698	1,343	5,367	160	6,870

* to end December.

Oranges.

The exports of oranges from Dominica and St. Lucia for the years 1934 and 1935 are set forth in Table V. It will be seen that there has been a marked increase in the number of crates exported from Dominica. This increase is in part due to the provision of adequate cold storage space on the Canadian National Steamships. The demand for West Indian oranges in Canada has noticeably improved and several f.o.b. orders for Dominica oranges were unfulfilled owing to lack of fruit.

Table VI.—Grapefruit.

	Trinidad.	St. Lucia.	Dominica.	Total.
1931-32	11,425	83	2,015	13,523
1932-33	6,525	74	3,535	10,134
1933-34	30,414	35	5,958	36,407
1934-35	66,473	55	2,806	69,336
1935-36	—	92*	4,133*	—

* to end January, 1936.

Grapefruit.

The exports of grapefruit from Trinidad, Dominica and St. Lucia during recent years are set forth in Table VI.

Mangoes.

No improvement in the small mango industry was effected in 1935. The export figures are given in Table VII.

Avocado Pears.

Table VIII gives the export figures for avocado pears.

Vegetables.

Export figures for miscellaneous vegetables during 1935 are given in Table IX. Increased interest is being taken in the cultivation of tomatoes and carrots in Montserrat and it is estimated that 28,000 crates of tomatoes and 8,500 crates of carrots will be exported from that Island in 1936.

Table VII.—Mangoes (Crates).

Island.	1934					1935				
	Bermuda.	Canada.	U.K.	B.W.I.	Total.	Bermuda.	Canada.	U.K.	B.W.I.	Total.
Dominica ..	1,440	6	5	8	1,459	463	12	..	..	475
St. Lucia ..	3,535	288	298	3,760	7,881	3,372	334	465	2,385	6,556
Montserrat ..	111	..	..	22	133	243	..	..	57	300
St. Vincent	50	17	93	..	160	..	3	..	..	3
Total ..	5,136	311	396	3,790	9,633	4,078	349	465	2,442	7,334

Table VIII.—Avocado Pears (Crates).

Island.	1934			1935		
	Bermuda.	Elsewhere.	Total.	Bermuda.	Elsewhere.	Total.
Dominica	2,106	8	2,114	1,272	2	1,274
St. Lucia	2,241	4	2,245	3,850	7	3,857
Montserrat	131	4	135	54	..	54
St. Vincent. ..	78	..	78	..	..	..
Total	4,556	16	4,572	5,176	9	5,185

Table IX.—Miscellaneous Vegetables Exported during 1935.

Island.	Tomatoes.	Carrots.	Sweet Potatoes.	Onions.	Eschallots.	Pumpkins.	Pine-apples.	Mixed Fruit and Vegetables.
	Crates.	*Crates.*	*Crates.*	*Crates.*	*Crates.*	*lbs.*	*Crates.*	
Montserrat	18,631	3,002	1,042	522	166	..	..	..
St. Lucia	2	..	..	..	..	39,617	13	6,495 pks.
Nevis	794	..	..	..	..	..	..	42 brls.
St. Vincent	488	..	..	..	..	..	..	..
Total ..	19,915	3,002	1,042	522	166	39,617	13	..

Brevities.

Mr. G. A. Jones, Commissioner of Agriculture, visited the Leeward Islands (Antigua, St. Kitts and Montserrat) from 5th to 28th February.

* * *

Professor F. Hardy visited Antigua from 31st December to 3rd January to conduct further investigations in connexion with local soils.

* * *

Mr. W. O'B. Donovan, Agricultural Superintendent of Grenada, arrived in Trinidad on 15th January to take a refresher course at the College.

* * *

Mr. G. B. Gregory, formerly Agricultural Assistant, St. Kitts, has been transferred to St. Lucia as Assistant Agricultural Superintendent. Mr. Gregory assumed the duties of his new appointment on 9th February, 1936.

* * *

Mr. J. M. Cave, D.I.C.T.A., has been provisionally appointed as Agricultural Assistant, St. Kitts, in the vacancy caused by the transfer of Mr. G. B. Gregory to St. Lucia. Mr. Cave was formerly Field Assistant of the British West Indies Central Cane Breeding Station in Barbados.

Mr. L. G. Killby, Secretary of the Empire Cotton Growing Corporation, visited the Cotton Research Station in St. Vincent from 3rd to 10th March.

* * *

Sir Geoffrey Evans, Principal, and Professor E. E. Cheesman visited St. Vincent from 7th to 15th January in connexion with the work of the Cotton Research Station.

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Mr. C. C. Skeete, Assistant Commissioner of Agriculture, visited St. Vincent in January, and attended the third annual general meeting of the West Indian Sea Island Cotton Association as Secretary.

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Mr. A. Wimbush, Chief Forestry Officer of Madras arrived in Trinidad on 6th January, and proceeded on a tour of the Windward and Leeward Islands to examine and report on forest conditions in those Islands.

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Mr. G. A. Jones, Commissioner of Agriculture, visited St. Vincent for three weeks in December-January and presided over the third annual general meeting of the West Indian Sea Island Cotton Association.

CHEMICAL ASPECTS OF THE DECAY OF WOOD.

In *Chemistry and Industry*, Vol. LVI, 1935, p. 307, E. A. Rudge summarises his recent work on the decay of wood, and outlines his ideas on the causes and effects of decay under certain conditions. Until recently wood decay was believed to be caused by bacteria and fungi, either aerobic or anaerobic, but Rudge's experiments have shown that such organic effects may be secondary. In an extensive range of experimental work he has found that in general there is a rise in the inorganic content of the wood when it has decayed, and this increase cannot be accounted for entirely by the fact that the wood has lost part of its organic matter. Several general considerations common to a number of examples of decay are given:

(1) Decay will not occur unless the moisture content of the wood is of such an order that ionic conductivity is possible. As the moisture content of initially dry wood increases the electrical resistance decreases, until at some critical value there is a break in the slope of the moisture-conductivity curve, presumably due to a change in the function of the contained water. Above this critical value resistance falls very little with increase in moisture. For all woods examined this "critical moisture content" is about 20 per cent. of the dry weight of the wood and, this agrees with the empirical minimum previously determined below which fungi cannot germinate.

(2) Decay is always accompanied by an increase in ash content in the decayed wood. This may be due to two causes: (*a*) depletion of organic matter by wastage by micro-organisms, and (*b*) migration or infiltration of inorganic matter in solution towards the affected region. The first cause (*a*) must obviously obtain in cases of

fungus attack in situations entirely isolated from contact with sources of mineral matter, but it cannot be held to explain other cases of enhanced mineral content in antiseptic conditions, or where fungus action is negligibly small as in creosoted timbers. In the latter case, it can be due to fluctuations of mineral concentration corresponding to well-marked zones of cellulose deterioration.

(3) The inorganic compounds always associated with decay are the bicarbonates of calcium, magnesium, and iron. Other anions such as the chloride and sulphate have no effect, and it becomes apparent that of all the ions which may possibly make contact with wood under normal conditions of usage, the bicarbonate is specific in its association with decay. The importance of the cation lies solely in its ability to give a soluble bicarbonate.

These conclusions led ultimately to the formulation of a theory of decay based on ionic infiltration, which claims that in its incipient stages decay is brought about by the invasion of what has been called the "lignocellulose complex" by bicarbonates in solution. The complex is rendered unstable to atmospheric conditions and thereupon gives rise to degradation products. After this stage the type of decay depends on physical factors. Under aerobic conditions micro-organic attack may cause an advanced stage of decay referred to as "wet rot". If the timber is away from light, and at a suitable temperature and humidity, "dry rot" is the result. Under a third set of conditions, such as sterile or antiseptic atmospheres, the degradation of the wood proceeds more slowly than in the presence of fungi, the rate being determined by the temperature and the available concentration of oxygen. In totally submerged situations the chief factor determining the rate of decay is the concentration of bicarbonates, and since it can be shown that average hard water contains a lower concentration of calcium bicarbonate that average wood, submersion in such a water inhibits decay rather than promotes it.

Consequent on these findings, attempts were made to bring about the artificial decay and humification of wood under conditions definitely toxic to organic life. It seems that the first step in decay is the production of a complex formed by the interaction of the bicarbonate ion and the cellulose molecule, and this undergoes oxidations, producing two fractions: an insoluble complex containing the inorganic matter, and having the properties of uronic acids, and an easily hydrolysable fraction of the nature of humus.

The result of these investigations have been applied to the industrial aspects of timber chemistry. In the first place, seasoning assumes a new significance, for modern methods of kiln-drying are as a rule hit-or-miss processes. It can be seen that mere drying is undesirable, since it leaves within the wood all mineral matter inherent in the tissues and cell contents. Seasoning under water obviously owes its success at least in part to the removal of these substances by diffusion. Methods of preservation may also be reviewed from the standpoint of the theory, for it will be seen that the prevention of fungus attack is not the sole function of a successful preservative. In addition it should seal the pores against water, and it is probable that the failure of earlier methods employing solutions of toxic metallic salts was due in part to lack of appreciation of this factor.

In the application of timbers to building construction, the great importance of maintaining it out of contact with lime, plaster, and concrete is generally recognised. From the point of view of the infiltration conception, the reasons are obvious, but the situation must also provide sufficient moisture before decay can begin. If timber is embedded completely in a good quality concrete of low permeability exposed to the air, moisture will tend to move outwards towards the surfaces of the concrete, and the wood will remain sound for an indefinite period. On the other hand, if the timber is resting upon, or partly embedded in, a concrete which is in contact with a source of moisture, as in the case of a wet subsoil, water will move by capillarity or other effects into the wood, carrying with it in solution salts which are in practice found to be associated with decay. It is clear therefore that the character of the concrete very considerably affects the life of the timber in contact with it, and yet it remains a common practice to lay flooring joists direct upon a concrete of high permeability.

It is interesting to consider the relative resistance to decay shown by various kinds and species of timber, for this property is undoubtedly the resultant of many factors, such as texture, permeability, porosity, and the frequency and intensity of wet and dry conditions to which the wood is exposed, rather than to any inherent characteristic of the wood itself. The more putrescent woods are usually readily penetrable by water, whereas the resistant timbers are close-grained. Further enquiry points to the general conclusion that timbers with a high silica content, such as teak or greenheart, are more resistant to decay than those low in silica. The silica appears to be present as silicic acid attached to the cellulose molecule in much the same way as does the bicarbonate molecule in the process of decay, and this suggests that the selective adsorption of silicic acid protects the molecule from subsequent infiltration.

Rudge's work thus brings out the idea that wood will not decompose unless it contains a certain concentration of inorganic salts, bicarbonates being the most important. If a sufficient quantity of these substances is present, bacterial and fungal decay may follow with great rapidity. Methods of wood preservation should therefore aim at the prevention of infiltration of inorganic compounds, and the mere application of compounds toxic to micro-organisms is not sufficient to prevent decay.

D. W. D.

REVIEWS.

TROPICAL PLANTING AND GARDENING.

Fourth Edition. By H. F. Macmillan. *Macmillan & Co. Ltd.*, London, 1935, pp. 560, 25*s*.

This is the fourth edition of the popular text-book formerly called Tropical Gardening and Planting. The tribute of the public to the excellence of this work has been expressed in the clearest possible way by the speed with which successive reprintings have been called for, but the author has not been content to rest on his laurels and the present edition like each of its predecessors is extensively revised, and not only brought up to date, but moulded still closer to perfection. By this polishing process the total bulk has even been reduced by 35 pages whilst the subject matter has been considerably extended. The excellent photographs are again a feature of the volume, and the production is of Messrs. Macmillan's usual high standard.

Almost the only criticism that the reviewer can find to advance is against the title. Whilst of tropical gardening the volume is a veritable encyclopaedia it can in the nature of the case afford only the slightest of introductions to the major crops usually associated in the mind with the term "planting", and although what there is about such crops is excellently chosen, it was perhaps a pity to relegate gardening in the title to a subordinate place that it does not occupy in the book itself.

However, to a work with the reputation of this one the title is of little moment. All who know the older editions will welcome the new, and those who have not yet made the acquaintance of Mr. Macmillan as a guide to tropical and sub-tropical plants of all sorts, and how to grow them, will be well advised to do so forthwith.

E.E.C.

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THE FUNDAMENTALS OF CHEMICAL THERMODYNAMICS.

Part I. Elementary Theory and Electro-chemistry. By J. A. V. Butler, D.Sc., Lecturer in Chemistry, University of Edinburgh. *Macmillan*, London, 1935, pp. 253. Second Edition 7*s*. 6*d*.

This is a book on physical chemistry for the use of students who desire to obtain a thorough grasp of the fundamental principles underlying the theories of dilute solutions, electrode potentials, oxidation potentials and electrolysis. It would prove serviceable in the training of laboratory soil investigators and of sugar technologists. The subject matter is presented in a precise simple form, and in logical manner. A second volume to follow will deal more specifically with thermodynamic principles such as underlie the theory of heat exchanges, though the present volume introduces the thermodynamic method of reasoning at an early stage. Only a moderate knowledge of mathematics is necessary for a proper understanding of the subjects discussed. The book can be strongly recommended to those who prefer to study chemical and physical science from its foundations.

F. H.

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THE INTERNAL PARASITES OF DOMESTIC ANIMALS.

By Cameron, T. W. M. (T.D., M.A., Ph.D., D.Sc., M.R.C.V.S., Research Professor of Parasitology, McGill University, Director, Institute of Parasitology, MacDonald College, Canada), December, 1934. A Manual for Veterinary Surgeons, pp. XII + 292. 144 figures, 17 plates, 6 tables. (8 pp. references). London: *A. & C. Black, Ltd.* (15*s*.)

Professor Cameron is recognised as an authority in parasitology and his book will readily meet the requirements of veterinary surgeons as well as of students. The book covers considerable ground which may be surmised from the number of pages allotted to the various sections into which it is sub-divided: Part I, "Introduction to Parasitology", 9 pages; Part II, "The Protozoa", 30 pages; Part III, "The Helminths", 169 pages; Part IV, "Immunity and Serology", 20 pages; Part V, "Therapeutics of Helmintic Infections", 8 pages; Part VI, "Technique", 23 pages; Part VII, "Hosts Lists and Bibliography", 16 pages. The inclusion of the protozoa is an excellent idea and in these 30 pages a considerable amount of useful information is given: for this reason alone the book should be added to the library of all agricultural officers stationed in the tropics. It is also pleasing to see that special sections are assigned to Immunity and Serology as well as to Technique. The text reads well and the diagrams of the life history of the parasites will be most useful to students and to those about to start work on this important subject.

There are a few minor errors, but these can be corrected in a new edition. The book is a marked improvement on the text books available until recently on this important subject, and the price (15 shillings) is most reasonable.

H. V. M. Metivier.

Dr. K. Mellanby and Dr. P. A. Buxton direct attention to the occasional emanation, under the influence of moisture, of a poisonous gas from rubber washers used to seal the jars in which living insects are kept. This may vitiate experiments such as those on the influence of humidity upon the tsetse fly.—(*Nature*, Vol. CXXXVI, No. 3448, p. 874, 1935.)

CHEMICAL NOTES.

Compiled by the College Department of Chemistry and Soil Science.

Soil Investigation in Hungary.

The present relatively high price of soil investigations in Hungary prevents the full utilization of soil analyses, especially now that farmers cannot sell their products as advantageously as some years ago. From time to time various proposals have been made by experts to make soil analysis and fertilizer advice easier, quicker, and cheaper. A new method is described by Gy. Várallyay (*Mezógazdasági Kutátasok*, 8, 204-12, 1935) who proposes to examine the following factors of soils: specific gravity, pH in aqueous solution, calcium carbonate content, hydrolytic acidity, *Aspergillus* harvest on 5 grams of soil without phosphorous fertilization, the same with fertilization by KH_2PO_4 solution, *Aspergillus* harvest on 2.5 grms. of soil without potassium fertilization, the same with fertilization by potassium sulphate solution, and nitrate plus ammonia content of soil after storage for a month under given conditions. The method applied to the determinations with *Aspergillus niger* cultures was specially adapted by the author and is described in detail. The cost of determining the data is about one dollar, the time required about 3 hours when made in mass series determinations. The results seem to be sufficient to state whether the soil examined requires any fertilization or not, and what the variety and amount of the fertilizers should be. If the method is proved reliable, its cheapness will be a great advantage.—(*Ind. and Engin. Chem., News Edit.*, Vol. XIII, No. 23, p. 457, 1935.)

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Chemical Baits as Insect Attractants.

Re-investigation of chemical baits for attracting the Japanese beetle has shown that the combination of geraniol and eugenol is the most attractive. It was found possible to use a cheaper grade of geraniol. Rose geranium oil, eugenol, and tansy oil are definitely attractive to the Asiatic garden beetle (*Autoserica castanea arrow*) and may be tried in combination with light traps which are also attractive. This beetle has now spread westward to areas near Philadelphia, Pa. An interesting development in trapping the Japanese beetle is that traps painted green and white are superior to those painted with other colours.—(*Ind. & Eng. Chem., News Ed.*, Vol. XIII, No. 24, 1935, p. 475).

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A New Insecticide.

Sophora pachicarpa, a desert plant growing naturally in Central Asia and Kazakstan, has proved to be a rich source of an active alkaloid, "pachiparin", which may be used as an insecticide, according to recent investigations by the All-Union Research Institute of Fertilizers and Insectofungicides, U.S.S.R. The plant is widely distributed, and may be readily procured in large amounts. One acre of the crop produces nearly half a ton of green material. "Sophodust", as the preparation is called, has proved effective in controlling aphides.—(*Ind. & Eng. Chem. News Ed.*, Vol. 14, No. 1, p. 5, 1936.)

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Zinc Sulphate for Citrus Trees.

Dr. A. F. Camp, Horticulturist at the Florida Agricultural Experiment Station, Gainesville, Florida, has obtained striking results in the use of zinc sulphate sprays on citrus trees affected with frenching. Frenching is distinguished by a yellowing between the veins of the leaves, with the areas along the veins and edge of the leaf remaining green. If the trouble is severe, the leaves are very small and the twigs short, giving a bushy appearance to the tree. The twigs die back from the tip and are particularly susceptible to cold damage, even in mild cold spells. In the severest forms of frenching, large twigs and even branches die and the trees become progressively smaller, giving an extremely low yield of small hard fruit.

On a rather heavy soil, orange trees which had been carefully manured and cultivated, had never grown satisfactorily, but applications to the soil of one quarter to one half a pound of zinc sulphate twice a year gave a marked response, and normal growth and fruiting resulted in a short time. On the lighter soils of the Florida grapefruit area, however, the soil applications failed to give satisfactory results, and it was thought for a time that a different type of frenching was responsible for the poor growth. It was eventually discovered that the trees responded with exceptional rapidity to zinc sulphate sprays, giving vigorous growth in less than six weeks after the application. The most reliable spray was found to be a zinc-lime mixture of the following composition:—

5 lb. zinc sulphate (89 per cent. pure),
2½ lb. finely ground hydrated lime,
50 gallons water,
Calcium caseinate or blood added as spreader.

The zinc sulphate is dissolved separately by adding it slowly to a small amount of water with vigorous stirring. The hydrated lime is added gradually to the main bulk of water to make a good suspension, and the zinc sulphate added slowly to this, with thorough mixing. The spreader is either screened into the zinc-lime mixture or mixed separately with water, according to special instructions by Dr. Camp, from whom a copy of the complete circular on the subject of zinc sulphate for citrus trees may be obtained. A spray of zinc sulphate and water can sometimes be used successfully, but burning frequently results, and such a spray is not recommended. The amount of lime specified above is about the minimum that is thoroughly safe at all times.—(*Agricultural News Letter*, E. I. du Pont & Co., 1935.)

SUGAR NOTES.

Compiled by the College Department of Sugar Technology.

Cane Molasses (Sulphate, Copper and Iron Contents) —*S. J. Saint.*

With the object of evolving a chemical test which would detect differences which might exist between types of fancy molasses, 49 samples were examined for various constituents. The sulphate content due to the sulphates naturally present in cane juice would appear to vary from 0.2 to 0.27 per cent., the addition of sulphuric acid during the manufacturing process, in order to assist inversion raising the sulphate content to between 0.30 and 0.37 per cent. The copper content was found to vary between 1 and 14 parts per million; and the iron content between 8 and 200 parts per million. It cannot, however, be said that these results enable one to pick out the factory manufacturing a particular type of molasses.—(*Inter. Sugar Journal*, Vol. XXXVIII, No. 446, p. 70, 1936.)

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Uniformity in Reporting Factory Data.—*F. W. Zerban.*

This is a report of the special committee of technologists representing twelve cane growing countries, appointed to consider uniform methods for obtaining and reporting factory data. Only a small number of changes and corrections have been made in the original report, adopted at the previous conference of the association in Puerto Rico. By a majority report the "reduced extraction" figures proposed by Noel Deerr was recommended for adoption, but Deerr's proposition to introduce his system for comparing the efficiency of operation of different mills, in which the quantity of added water and the number of milling units are considered along with the fibre content, was turned down.—(*Facts About Sugar*, Vol. XXXI, No. 2, p. 66, 1936.)

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Removal of Evaporator Incrustations.—*F. W. Freise.*

The writer notes a method of removing evaporator scale that may be of interest to sugar factories in the neighbourhood of mangrove swamps. This method consists in chopping up fresh bagasse (not over two days old) into pieces 1 to 1½ inches long and mixing the pieces with two per cent. of their weight of crushed shells of decaying mangrove fruits (from *Rhizohora mangle*). The combined mixture is then stirred into eight or ten times its weight of water and pumped into the evaporator body in sufficient quantity to submerge the heating unit. Fermentation starts at once, due to the presence on the mangrove hulls of a particular micro-organism that vigorously attacks sucrose and cellulose, with formation of butyric and some formic acids. These acids which are not noticeably harmful to metal, dissolve much of the scale and loosen the rest so that it can be flushed out with a jet of hot water. In no case was more than 20 hours required to complete the action.

Another cheap method available to tropical sugar factories located in the vicinity of "black water rivers", is to pump this black water slowly through the evaporator for several hours. These black waters carry in solution the results of anerobic fermentation of vegetable matters, and often have an unusually high content of formic, acetic, propionic and lactic acids.—(*Facts About Sugar*, Vol. XXXI, No. 2, p. 66, 1936.)

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Turbidity in Sugar Products.—*F. W. Zerban, L. Sattler and I. Lorge.*

The formulae developed in the previous paper, for calculating the concentration of colouring matter and turbidity in a certain raw sugar from the transmittancy and Tyndall beam intensity of its solution, have been applied to 62 other raw sugars. It has been found that the results obtained by this method check with those of Balch's method only in those cases where the properties of the particles causing the turbidity are the same as in the standard sugar. Conversely the discrepancy between the results of the two methods serves to characterize the particle properties. It is of course fully realized that neither the colour nor the turbidity problem in sugar products can be completely solved without further fundamental knowledge of the chemical and physical properties of the constituent dispersoids present as turbidity or colouring matter, and the procedure outlined in this paper is presented merely as a step in that direction.—(*Int. Sugar Jr.*, Vol. XXXVII, No. 439, p. 272, 1935.)

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Acclimatization of Yeast.—*H. S. Chaturvedi.*

At the suggestion of Dr. Wm. L. Owen, experiments were undertaken to determine to what extent yeast can be acclimatized to withstand the adverse conditions of high temperature and high alcohol content, so as to give the same fermentation efficiency in tropical as in temperate countries. It was found in one experiment that a yeast giving an efficiency of 83.5 per cent. declined when the conditions were made more severe to give one of only 63.7 per cent. But, by gradual adaption from one fermentation series to another, it became perfectly acclimatized, so as to give the same efficiency under both unheated and heated conditions. A series of six fermentations was necessary. It was found that the use of fresh pineapple juice in the culture medium gave a more efficient variety of acclimatized yeast, having an even higher fermentation efficiency than its parent.—(*Int. Sugar Jl.*, Vol. XXXVII, No. 443, 1935, p. 452.)

TREND OF THE MARKETS.

[The notes below are based principally upon running charts of the prices of the basic grades and upon general statistical information gleaned from contemporary publications and cablegrams and are intended to be a record of movements. An attempt is made, where possible, to indicate the market outlook at the time of going to press, but no responsibility for the accuracy and subsequent truth of such observations is assumed. Unless otherwise stated the prices quoted are spot, London.]

SUGAR.—Prices on the Home Markets have ranged as follows (c.i.f. per cwt.)

	Foreign.		*Preferential.*	
	s.	*d.*	*s.*	*d.*
30th January	5	0¾	8	9¾
6th February	4	11¼	8	9¾
13th February	4	10½	8	6¾
20th February	4	9¾	8	6¾
27th February	4	8¼	8	6¾
5th March	4	7½	8	4½
12th March	4	9¾	8	6¾
(14th *March*, 1935)	4	3	8	4½

The market has turned quiet and rather easier. A fair business was done at lower quotations and values made a partial recovery but the improvement was not maintained and further weakness set in. The setback was rather unexpected in view of the improved international statistical position. Prices would appear to have been influenced by the continued indifference shown by buyers generally and by the seasonal congestion of Empire supplies. The unsettled condition of sugar affairs in the U.S.A. has also not been without its effect.

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RUBBER.—Quotations for Plantation Sheet have ranged as follows:—

	Pence per lb.
29th January	7
5th February	7 1-16
12th February	7 1-4
19th February	7 5-8
26th February	7 5-16
4th March	7 7-16
11th March	7 1-2
(13th *March*, 1935)	5 15-16

The tone of the market has been steady to firm with a gradual rise in prices. Steady buying by American manufacturers has been one of the main features. Prices subsequently eased slightly as a result of the Supreme Court's decision in the Tennessee Valley Authority Case in U.S.A. which upset the market in "Utility" shares and had unfavourable repercussions on the most speculative commodity markets. According to the American *Questionnaire* consumption in January at 48,506 tons was better than had been expected.

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COFFEE.—Mostly Costa Rica, Kenya and Tanganyika have been offered for sale. There has been a good demand on the whole and good qualities found a readier sale at improved prices in some cases. Less attractive parcels difficult of sale. Up to 125*s*. per cwt. paid for fine Costa Rica and 133*s*. per cwt. for bold Kenya. Superior Santos 41*s*. 6*d*. per cwt.

COCOA.—The market abroad for cocoa has been rather dull during the past fortnight but locally a firm and active market has been maintained and as high as $7.50 per fanega has been paid. This no doubt is due to the fact that the crop is short and dealers are buying all they can lay their hands on, as the general impression is prices may go even higher now that the bulk of the crop has been reaped. Accra cocoa is being quoted at 24*s*. 3*d*.—(*By Courtesy of the Cocoa Planters' Association of Trinidad, Ltd.*)

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COTTON.—The following are the official spot prices in pence per lb. of the Liverpool Cotton Association.

	American Mid.	*Egyptian F.G.F. Sakel.*
31st January	6.14	9.69
7th February	6.07	9.51
14th February	6.21	9.18
21st February	6.17	9.07
28th February	6.04	9.03
6th March	6.02	—
13th March	6.26	—
(15th *March*, 1935)	6.59	8.40

The tone of the market has been very irregular, trade being slack, largely owing to distrust of raw cotton prices. Traders have been puzzled also by the diverse reports from the U.S.A. as to the Government's future action. The Egyptian premium appears unduly high against other staples. There has been a good enquiry for West Indian Sea Island but an absence of supplies.

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BANANAS.—Extremely cold weather continues to affect demand. Jamaicas unchanged at £15 5*s*. per ton delivered London and £15 nearest station. Brazilians £1 lower at £11 delivered nearest station.

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COPRA.—Market quiet with West Indian f.m.s. valued nominally at £15 5*s*. for spot and forward.

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CITRUS PRODUCTS.—*Lime Oil.*—Handpressed is very slow of sale. The nominal value is 35*s*. per lb. The demand for Distilled is disappointing and supplies at 22*s*. 6*d*. have not been absorbed.

Lime Juice.—There is a limited inquiry for Concentrated, but no offers are available. Raw is quiet, but steady and unchanged at 2*s*. and 2*s*. 6*d*. for good to fine.

Orange Oil.—There are sellers of Sweet at 6*s* 6*d*. c.i.f. but no demand. There is no demand for Bitter, and sellers are inviting bids.—(*West India Committee Circular*, 13th February, 1936.)